consulting engineer

June 1955

Naef of Zurich

ROBERT A. NAEF is a Swiss consulting engineer with an international practice. His headquarters are in his home town of Zurich, Switzerland. He deserves the attention of American consultants—not only for his outstanding engineering achievements—but because of his position as President of the International Federation of Consulting Engineers. He represents the interests of approximately 2500 consulting engineering firms in ten of the major European countries.

Continued on page 6

The Consulting Engineer's Professional Magazine

STEEL FORGINGS by MESTA

for HIGH PRESSURE and HIGH TEMPERATURE PIPING

custom made to your mechanical and metallurgical specifications

Y's

TEES

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VALVE BODIES

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MESTA FACILITIES for Forged Steel Piping

Electric Steel and Open Hearth Furnaces
Forging Presses • Heavy Duty Machine Tools
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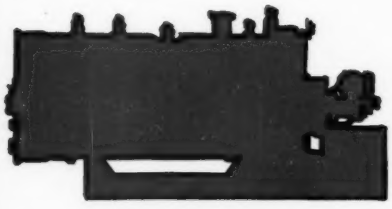
Complete Testing Equipment

ROLLING MILLS • ROLLS • FORGINGS • HEAVY DUTY TOOLS

MESTA MACHINE COMPANY

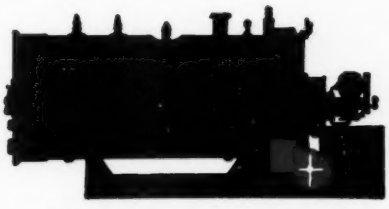
PITTSBURGH, PENNSYLVANIA

HOW SUPERIOR SOLVES YOUR STEAM PROBLEMS



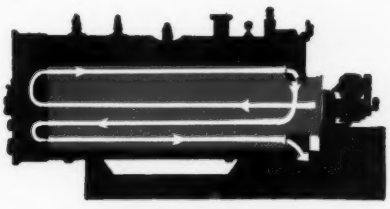
A COMPLETE PACKAGE

Completely factory-assembled and tested, a Superior Steam Generator is backed by undivided responsibility.



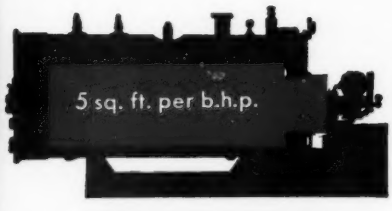
INDUCED DRAFT THAT'S BUILT-IN

... eliminates need of an expensive chimney ... Multiple fans draw evenly on all tubes, reducing maintenance.



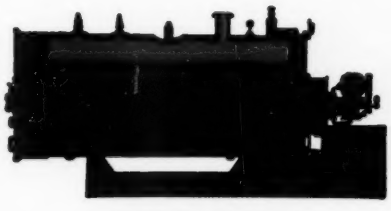
4-PASS, DOWN-DRAFT DESIGN

High gas velocities produce high efficiency. Down-draft design promotes rapid evaporation, quicker steaming.



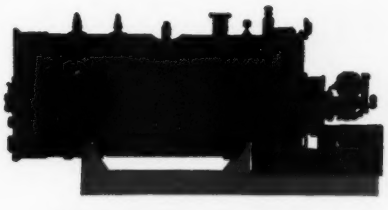
AMPLE HEATING SURFACE

A minimum of 5 sq. ft. of heating surface per boiler horsepower assures maximum efficiency at full rated capacity.



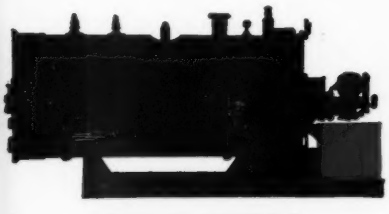
RESERVE CAPACITY

Greater steam space and large evaporating surface provide ample reserve capacity & better than 99% dry s. am.



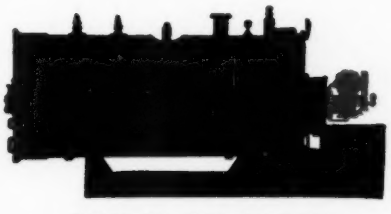
NO EXPENSIVE FOUNDATION

Built on a rigid channel iron base, a Superior Steam Generator needs only a floor capable of supporting its weight.



BUILT-IN CONTROLS

All controls essential to completely automatic operation are factory-wired into an easily accessible control panel.



BURN OIL, GAS, OR BOTH

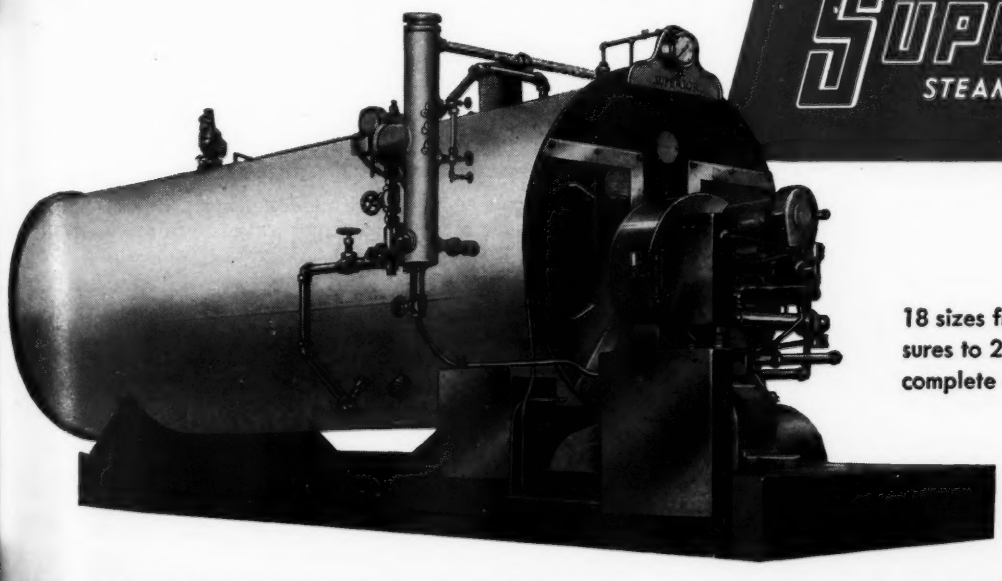
Superior Burners burn oil or gas or a combination of both ... changing from one fuel to the other in seconds.

Superior Steam Generators are the ideal choice for a new steam plant ... the simplest answer to expanding your present plant ... the easiest solution to replacing obsolete boilers.

Guaranteed to develop maximum rated capacities at thermal efficiencies in excess of 80%, their design embodies features which insure long-lived dependability and maximum fuel economy.

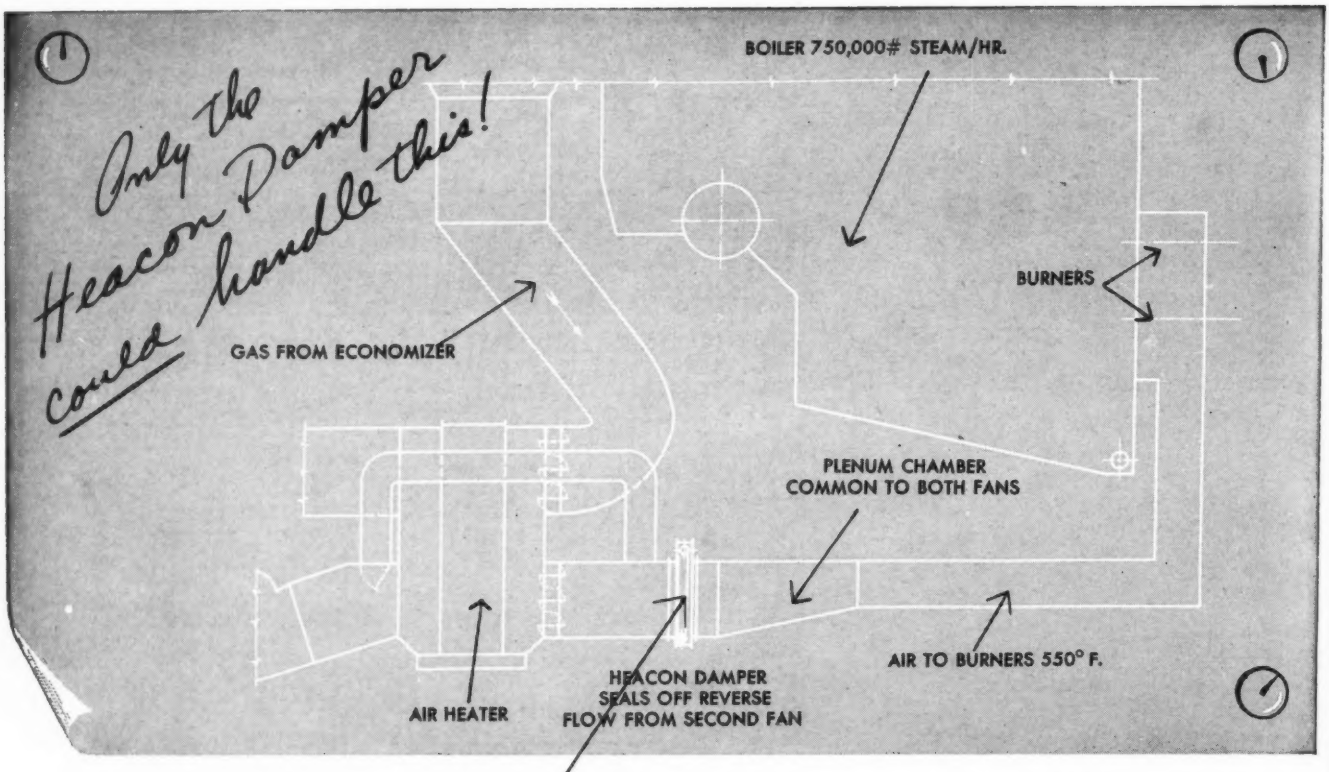
for performance you can ***BANK*** *on*

SUPERIOR
STEAM GENERATORS

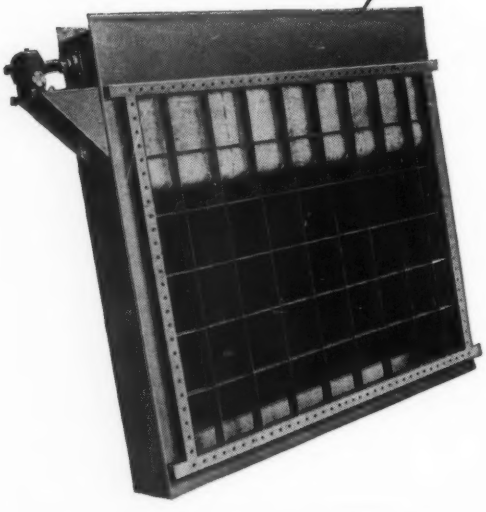


18 sizes from 20 to 600 b.h.p. for pressures to 250 p.s.i. or for hot water. For complete details write for Catalog 707.

SUPERIOR COMBUSTION INDUSTRIES INC. **TIMES TOWER, TIMES SQUARE, NEW YORK 36, N.Y.**



One of Two Air Pre-Heaters cleaned *while* Boiler operates at half load



THERMIX HEACON

There's a big difference in temperature between the inlet and outlet sides of this Heacon Damper installation when the damper is closed. There has to be because in this large western utility, air pre-heaters are cleaned while the boiler operates at half load!

This is made possible only because Heacon Dampers can effectively shut off high temperatures without leakage . . . can assure safety of personnel while boiler is in operation.

No other damper could assure the tight sealing so necessary in this installation. No other damper could provide these important benefits:

1. Quick return on investment through savings realized by operating steam generator at one-half load or better during cleaning operation.
2. Elimination of internal strains and possible damage during complete boiler shut-down.
3. Safety of personnel during cleaning operation.

Performance will prove to you as it has for others that Heacon Dampers are the most efficient dampers available anywhere. *Performance* in this installation resulted in 6 repeat orders for a total of 25 dampers!

Heacon Dampers are designed and constructed to meet practically any pressure or temperature specification. Our engineers will be glad to discuss your damper problems with you.

Project Engineers

THE THERMIX CORPORATION
GREENWICH, CONN.

(OFFICES IN 38 PRINCIPAL CITIES)

Canadian Affiliates: T. C. Chown, Ltd. 1440 St. Catherine St. W., Montreal 25, Quebec. 983 Bay St., Toronto 5, Ontario, Canada

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JUNE 1955

FEATURES

DEPARTMENTS

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Naef of Zurich

—Starts on front cover

Since he was elected to the post of President in 1950, Robert Naef, in his quiet and modest but nonetheless persistent manner has worked hard to consolidate the membership of the International Federation so that it can effectively represent the interests of the consulting profession.

For example, not long ago the International Federation of Contractors asked the Consulting Engineers Federation to help them establish a general set of contract conditions that could be followed when working on foreign projects. Currently, contractors and consultants in each country have their own differing practices covering such controversial points as payments, measurements, and authority of the directing engineers. Obviously, if consultants and contractors can agree on a general European code, it will greatly simplify their negotiations and future relations with their clients and with each other. The formulation of this general code has now been under study by both sides and will be discussed shortly in a joint meeting in Paris. By the end of the year, Naef hopes that a final acceptable draft can be presented to both Federations.

Naef, a tall, gaunt man of 56, looks far younger than he is. His interest in languages (he speaks fluent English, French, Spanish, and Italian) goes back to his early high school days, when he majored in Latin and Greek. However, by the time he was ready to enter college, his interest had switched to engineering. At the ETH (Eidgenossische Technische Hochschule), Switzerland's foremost school of engineering, he specialized in the study of bridge engineering.

Engineering Projects

As an independent consultant, Naef has been responsible for the structural design of a number of interesting buildings in Zurich, including the well known Hallenstadt, or indoor sports stadium. He has been retained as a consultant on community development projects in the Middle East and is presently an advisor to Spanish clients concerning their program of power plant expansion and industrialization.

When Robert Naef returned to Switzerland from France to open his own office in the '30's, he took a keen interest in the activities of the Swiss Association of Consulting Engineers and served for several years as Secretary of the Association. In 1938 he was elected President of the Swiss Association and at the same time was made a delegate to the meetings of the International Federation.

During this period, and in fact ever since it was founded in 1913, the International Federation of Consulting Engineers had been thought of as practically a social group. Its members and leaders, generally were older or retired men.

World War II changed a lot of things — besides the face of Europe. Many pre-war Continental ideas and institutions were severely jolted. Reconstruction and Dollar Aid, closely followed by U. S. engineers and technical knowledge probably contributed substantially to the rapidly growing prominence of European consulting engineers. Individually, these consulting engineers struggled for, and in many cases won, jobs previously denied to them. Collectively, through their National Associations of Consulting Engineers and through the International Federation, they began to assert their independent professional status.

In 1946, at a meeting in Amsterdam, the Federation continued the reorganizing work (among other things, they gave more power to the President). By 1950, when Naef became President of the Federation, the times were more appropriate, and the Federation was better prepared to aggressively pursue the interests of its membership. They had provided consultants with a voice in world councils along with such other bodies as the United Nations, the World Bank, and OEEC (Organization for European Economic Cooperation). They have collaborated with groups such as the International Federation of Contractors, and they have made every effort to establish a high standard of professional ethics.

Closer Contact With U.S.

Probably one of the most important and immediate aims of the Federation is to establish closer contact with American consultants. Interested in establishing a contact with American consulting engineers and their associations, the Federation, early in 1953, wrote a letter to the American Institute of Consulting Engineers inviting their participation in the Federation. The suggestion was turned down.

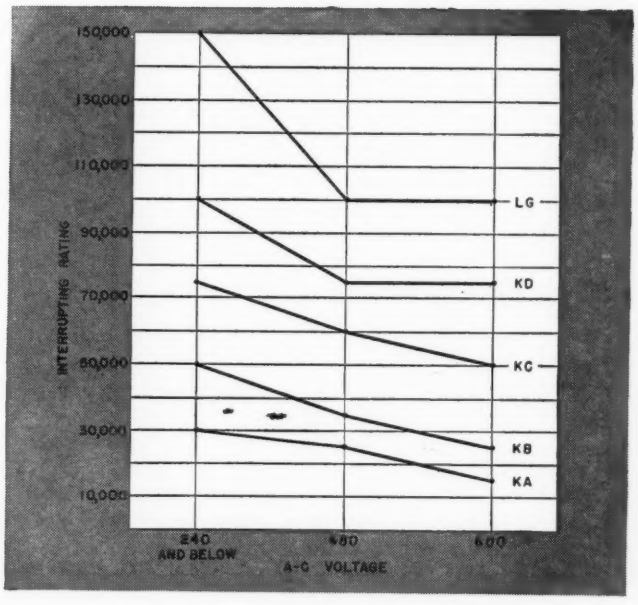
"Nevertheless," says Naef, "I think that American consulting engineers should be represented in the International Federation, and we would certainly welcome the opportunity to come into closer touch with American engineers and their ideas. I also see many possibilities for exchanging information between our individual member firms and U.S. firms, perhaps even cooperating on foreign projects. The Federation could provide a common meeting ground while at the same time maintaining and promoting the over-all professional interests."

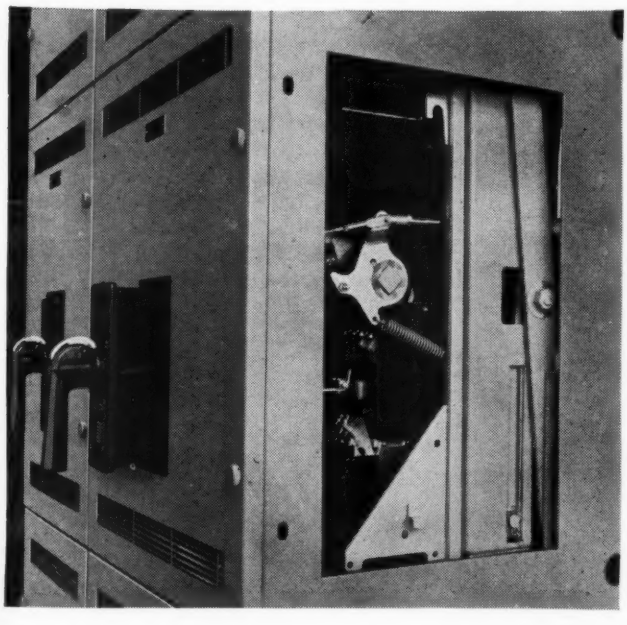
The organization and aims of the International Federation of Consulting Engineers are sound. They have successfully ignored the political and economic boundaries and national interests and prejudices in winning the support of the majority of independent consulting engineers in Europe on the platform of common professional interests. Prestige and recognition have followed.

I-T-E Low Voltage Switchgear

Circuit breaker interrupting ratings increased in keeping with proposed industry standards

You save, because these standards reduce switchgear costs by permitting the use of lower interrupting rating breakers for short circuit protection in 240 v a-c and 480 v a-c systems. And with smaller breakers you save space, too. Uprating of I-T-E Types KA, KB, KC, KD and LG Air Circuit Breakers is shown in the accompanying chart.





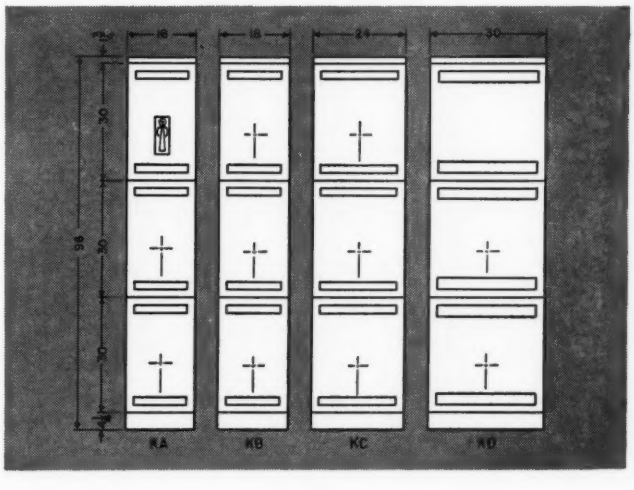
Test position with doors closed now standard on new switchgear

Test position with no increase in over-all switchgear depth! This facility is by far the most convenient, most compact design on the market. It is an exclusive with I-T-E Switchgear, yet it costs no more. Additional advantages are increased safety, reduced maintenance, improved cleanliness, easier circuit identification.

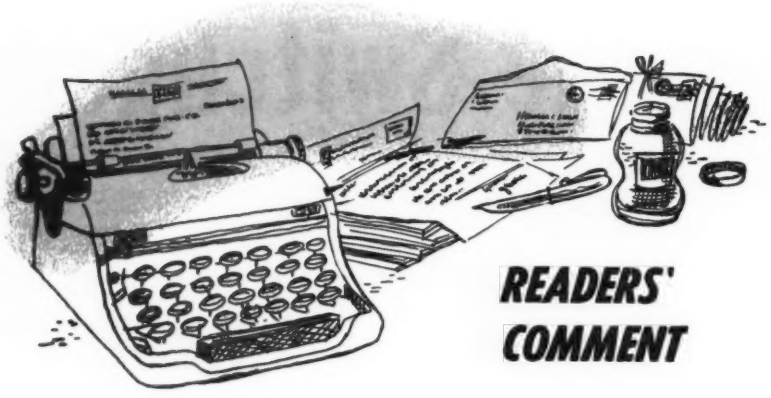
New compact breaker design saves space

All I-T-E Type K Circuit Breakers can now be assembled three-high. KA, KB and KC frame widths remain the same as before. However, the new KD breaker is 6 in. narrower than the old LG frame, and can be arranged in a three-high compartment, space being thus provided for instrumentation in the same frame.

For complete information, contact your nearest I-T-E field office. Or write I-T-E Circuit Breaker Company, 19th and Hamilton Sts., Phila. 30, Pa.



I-T-E CIRCUIT BREAKER COMPANY · Switchgear Division



READERS' COMMENT

Expansion Joints

Sir:

In your March, 1955 issue, statements in the otherwise informative article entitled "Design Data for Expansion Joints" might lead youthful engineers to believe that expansion joints are still used solely for axial deflections. This is pointed out by the statement "Expansion Joints, regardless of type, require good pipe alignment to perform satisfactorily." Secondly, another misleading statement is made with reference to pipe guides: "In bellows-type joints, it prevents the excessive stresses on the bellows that develop with lateral and angular misalignment of pipe."

The first statement is partially true, but only when an expansion joint is specifically applied to a system rigidly tied down so as to function in the old-fashioned straight axial manner. However, in modern piping systems, such as Marquette Free-Floating Piping Systems and several others, piping is freely supported only, eliminating pipe guides and resulting in low reaction anchorage. Where expansion joints may absolutely be required due to space confinement or other factors, special bellows-type expansion joints are applied to specifically accommodate lateral and/or angular expansion vectors in one or more planes. In addition, anchors are often eliminated from the systems entirely. This results in the safest strain-free system and in lowest overall cost to the ultimate user, especially at elevated pressures and temperatures.

The second statement is actually far from true as published reports of strain gage tests on bellows-type expansion joints (specific designs) conclusively prove that the corrugations in such bellows are actually under much less deflection stress when they accept lateral and angular movements than when they must absorb axial deflections.

It is becoming increasingly more common to avoid using expansion joints in piping systems to absorb straight axial expansion. The newer practices of using them for lateral and angular deflections have come about not only through availability of new designs of joints, but also because piping designers themselves, conscious of piping flexibility factors, have learned to properly adapt joints to existing and new systems, rather than to make the piping system conform to the expansion joint requirements. The principles learned from piping flexibility studies are well applied for using expansion joints in the most efficient manner.

C. M. Heller, Chief Engineer
Piping Design Division
Marquette Coppersmithing Co.
Philadelphia, Pa.

Phone Listings

Sir:

In the April issue under the title Scraps & Shavings on page 14 you mentioned the Philadelphia phone book as the only one you have found that carries a statement in regard to the fact a license is required to practice engineering.

The Portland, Oregon phone book carries the following statement on page 170 of the "Yellow" portion:

"THE OREGON LAW DECLARES IT UNLAWFUL FOR A NON-REGISTERED individual to practice or advertise to practice Professional Engineering in any branch, or Land Surveying, or to use any title conveying the impression that he is a Professional Engineer or Land Surveyor. For information concerning registration

call

ENGINEERING EXAMINERS
STATE BOARD OF OREGON
Portland, Oregon"

Further, the State Board of Engineering Examiners pays for this statement to be printed. It is printed regularly. Also, the Board like-

FENESTRA TROFFER-ACOUSTICAL PANEL SYSTEM CUTS COST OF REINFORCED CONCRETE SCHOOL CONSTRUCTION

Multi-purpose Steel Panels provide long-span forms for concrete joists *plus* acoustical ceilings and recessed lighting troffers *built right in!*

Multi-purpose is the key to economy in school construction. The NEW Fenestra* Troffer-Acoustical Panels (TAC Panels, for short) are designed for multi-purpose use of materials and construction labor. They permit you to have acoustical treatment and lighting—features that usually require extra time and labor—*built right in the structure itself.*

Money is saved because 3 expensive building materials are wrapped up in these economical building panels: (1) the forms for concrete joist construction, (2) metal pan acoustical ceilings, and (3) recessed lighting troffers.

Time is saved because the structural floor for the rooms above and the acoustical ceiling and lighting system for the rooms below are completed at the same time . . . with only paint, finished flooring and installation of fluorescent fixtures to be done after the concrete has cured.

And, this new building system gives you better-looking, better-lighted classrooms that are easier to maintain, year after year. The ceilings can be washed or repainted as often as needed, without affecting the acoustical treatment. There is no hanging ceiling or "stuck on" acoustical material to be damaged or replaced.

Investigate the New Fenestra TAC Panel System now. Even if you have plans on the drawing board, they may easily be adapted to use it. Write today for your copy of the new brochure, *Fenestra TAC Panel System.* Detroit Steel Products Co., Dept. CE-6, 3443 Griffin Street, Detroit 11, Michigan.

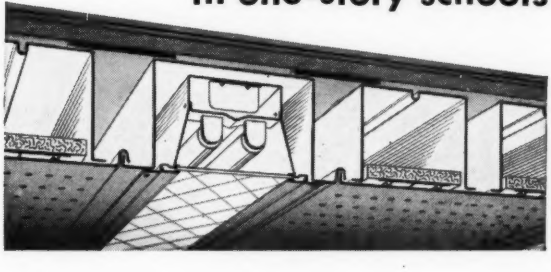
*Trademark

NEW! TROFFER PANEL for Fenestra "D" Panel Construction in one-story schools

Now you can have *built-in* troffer lighting in one-story school buildings designed with Fenestra Type "D" Acoustical-Structural Building Panels.

Standard troffer lighting fixtures may be installed flush with the acoustical ceiling in this new Type "D" Troffer Panel, eliminating hanging fixtures and exposed wiring conduits.

Write Detroit Steel Products Company, Dept. CE-6, 3443 Griffin St., Detroit 11, Michigan, for your copy of the new book, *Fenestra for Schools,* and for complete details on this new Troffer Panel.



Fenestra

TAC

TROFFER-ACOUSTICAL

BUILDING PANELS

wise prints the same statement in other directories in the State, possibly six or eight. We have found the phone company very cooperative in the listings in Portland as they normally check with the Secretary before a new name is listed.

H. Loren Thompson, Member
Board of Engineering Examiners
Portland, Oregon

In The Public Domain

Your interesting and valuable magazine in the April issue contains an article called Scraps & Shavings to which I feel I should protest.

I know there is a wide-spread belief among registered engineers in support of your statement that "only registered engineers can offer engineering services under the law" without specifying the type of service. I am sure that no competent authorities in jurisprudence would hold the statement true under our Federal Constitution. I would suggest that you secure juridical advice before using a sweeping assertion.

Actually, the states may legislate in such matters only to the extent reasonably necessary to protect "innocent third parties" from hurt arising from faulty construction. Hence registration of practitioners is applicable only to the design of structures to which the public has access and to which it has a right to expect its safety to be assured.

Although I believe all engineers should be registered in their States of residence and belong to their engineering societies, I do not believe it is wise for us to mislead ourselves as to the scope of our ability to dictate terms of occupation.

The title of "Engineer" is in the public domain by reason of long-established acceptance. It has been an honor awarded by universities upon completion of a required course of study for centuries. It has been used and accepted in many other connections. Public opinion would be generally opposed to any attempt by us to force an old and very strong labor union to change to Brotherhood of Locomotive Operators.

The title sub-script of "consulting" is equally in too general usage to enable us to preempt sole ownership at this late date.

The only definitive description available to us as I see it is "Registered Engineer" with whatever modification we may see fit to add to identify the specific field of the complex in which we operate.

Herbert B. Addington
Herbert B. Addington and Associates
New York, N.Y.

propeller-fan heater

of industrial and commercial unit heaters . . .

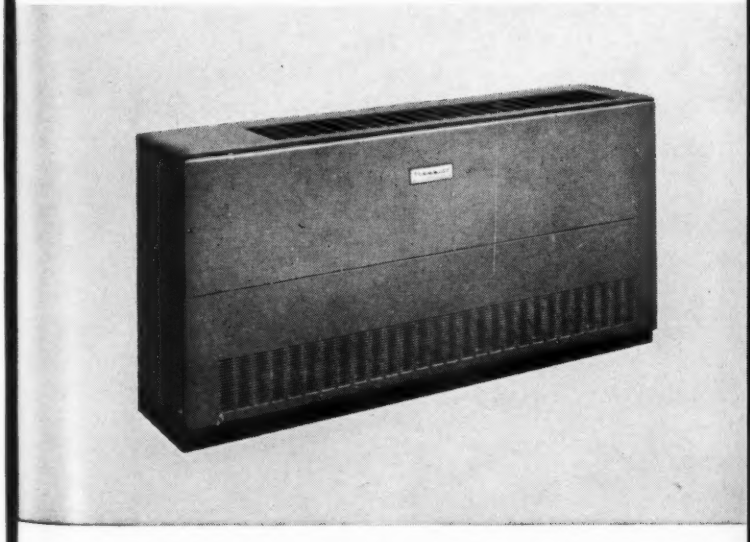
This wholly new Nesbitt propeller-fan unit heater offers an unusual combination of values in construction, performance, appearance and cost.

Its *universal* heating coil of continuous tube design *performs equally well with either steam or hot water*—an innovation that cuts inventory and warehousing costs in half.

Exact selection is simplified by the choice of 24 models (eight basic sizes) with capacities ranging from 15,000 to 335,000 Btu/hr. Pub. 401.

A careful study of the partial list of special features on the opposite page is recommended. It will explain why these new units are extremely flexible in their application, easy to install, surpassing in performance, quiet, long-lived, economical, and fit for the finest interiors.

The advanced styling and performance of all Nesbitt Unit Heaters is the result of over forty years of progressive engineering and technical improvement—to help keep you in the lead.



SERIES C UNIT HEATERS . . . Five sizes, 34" to 74½" long, each with choice of two steam or one hot-water heating element; two to five fans; recess, semi-recess, and non-recess fronts; 35,100 to 148,000 Btu/hr. Pub. 403.

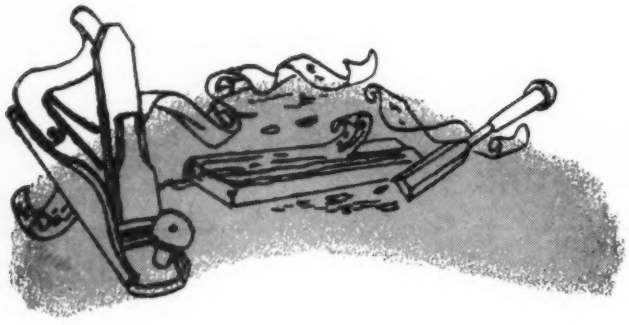
GAS-FIRED UNIT HEATERS . . . Seven models, 25,000 to 200,000 Btu/hr input, 400 to 2900 cfm; A.G.A. and U.L. approved for all gases; most advanced styling and many features to simplify installation. Pub. 280.

think first of this name

Nesbitt

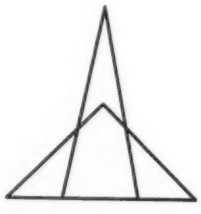
INDUSTRIAL UNIT HEATERS

Manufactured by
John J. Nesbitt, Inc., Philadelphia 36, Pa.
Sold by Leading Wholesalers—Information on request



SCRAPS & SHAVINGS

LAST MONTH the University of Wisconsin held a seminar on Engineering Organization. At one of the sessions, a prominent Management Consultant lectured on engineering personnel problems. At one point in his talk, he drew a diagram on the board.



The altitude of each triangle represents an engineer's technical ability, his knowledge of basic engineering. The width of each base represents the ability of the engineer to handle men, to supervise the activities of others. The tall, narrow triangle pictures an engineer with great technical skill but little aptitude for management. The low, broad triangle is an engineer with only average technical ability but broad management skill.

This lecturing management consultant pointed to the tall triangle and said, "I can hire these men for a dime a dozen." Then pointing to the broad triangle, "These are the men we need—men who can handle other men. These are the engineers who will make the money."

Unfortunately, what he said was true. It is possible to hire technically outstanding engineers for "a dime a dozen" despite the widely proclaimed "shortage" of engineers. It is also true that engineers as managers are much more highly paid than those in production, design, or research and development. A survey by the National Society of Professional Engineers (1953), shows a median figure of $9,930 for engineers in executive-administrative work; $6,960 for those in production; $7,160 for design; and $7,390 for research and development. This survey was made among registered engineers of all age groups. The figures support the position taken by the lecturer at the Engineering Organization Seminar.

We have no quarrel with the facts. They are as they are. We question whether they are as they should be.

The engineer is a professional man. He therefore has advanced proficiency in a particular field of knowledge through which he serves the public and is paid for his services. Yet, it is a fact that engineers are paid more for handling men (a field in which they have no special training) than for work in applied science (for which they are trained and are expert). This is not as it should be. If you were to find yourself in need of an operation and you started looking around for a surgeon, which would you select, Dr. Brown, who is highly skilled in surgery, or Dr. Smith, who is well known for his ability to handle men? You would pick the skilled surgeon, and you would pay him for his skill. You would not give a happy damn whether he was a good executive or manager or whether he belonged to the Rotary Club.

The same is true for lawyers. When you need a lawyer, you get a man who is an expert in the field in which you are involved. It is the least of your worries if he happens not to get along with his partner or his stenographer or if he is a total wash-out as a manager of men.

Only the engineer is different. He gets paid for his managerial and executive ability. It is illogical, and it leads to technical stagnation and professional disintegration. Had General Electric tried to hire Steinmetz on the basis of his managerial ability rather than his technical genius, he never would have been employed, and GE would have been the loser. The possibility for examples is endless.

We all admire a man who has managerial ability. It is an excellent quality. But it is not the only ability worth money. The doctor and the lawyer are paid for their knowledge and skill in their profession. It should be the same for engineers. We cannot expect this fortunate state to come about of its own accord. We must put a higher value on technical proficiency. The American Society for Engineering Education and the Engineers Council for Professional Development must work to see that fewer and better engineers are graduated from schools offering longer and more intensive curriculums of the type now offered at only a few schools, such as Cal Tech—and perhaps Stevens. Degrees should only be given on a graduate level as in law and medicine. The degree of Bachelor of Engineering should be dropped. A degree in technology, a sub-professional degree, could be substituted — it would be somewhat equivalent to the medical technician.

This is what we need if the engineer is to be paid for his knowledge and skill, as every professional man should be. Management is another field again.

the Legal Aspect

MELVIN NORD
Consultant in Legal and Technical Problems
Registered Professional Engineer
Patent Attorney

Labor Law: Historical Background

IN THESE DAYS of the Guaranteed-Annual-Wage debate, engineers are forcibly reminded of existence of a branch of law known as Labor Law, which permits unions to bargain collectively and which requires management to do the same. Labor Law is one of the really new branches of the law — so new that it has only recently become respectable to know anything about it. And it is one subject about which engineers need be informed.

Labor Law is too new to be as well settled as, say, the law of contracts, or of master and servant. It is still a political and an emotional issue, as well as a legal subject. Because it is in such a state of flux, it is impossible to gain a proper appreciation of the subject without first putting it in perspective. In the present column we will attempt to provide a brief synopsis of the historical background of Labor Law, and in the columns that follow, we will try to find out where we are and where we are heading.

Analogies Used

The most important historical fact about Labor Law is that there was no such animal before the Industrial Revolution. Yet, starting about 1800, law cases arose in which the judges were called upon to decide whether or not the early attempts of labor to organize were illegal. There was really no "common law" to which the judges could turn for precedents because this was basically a new fact situation. And of course there were no statutes on the books that could be applied. As a result, judges were forced to fall back on analogies.

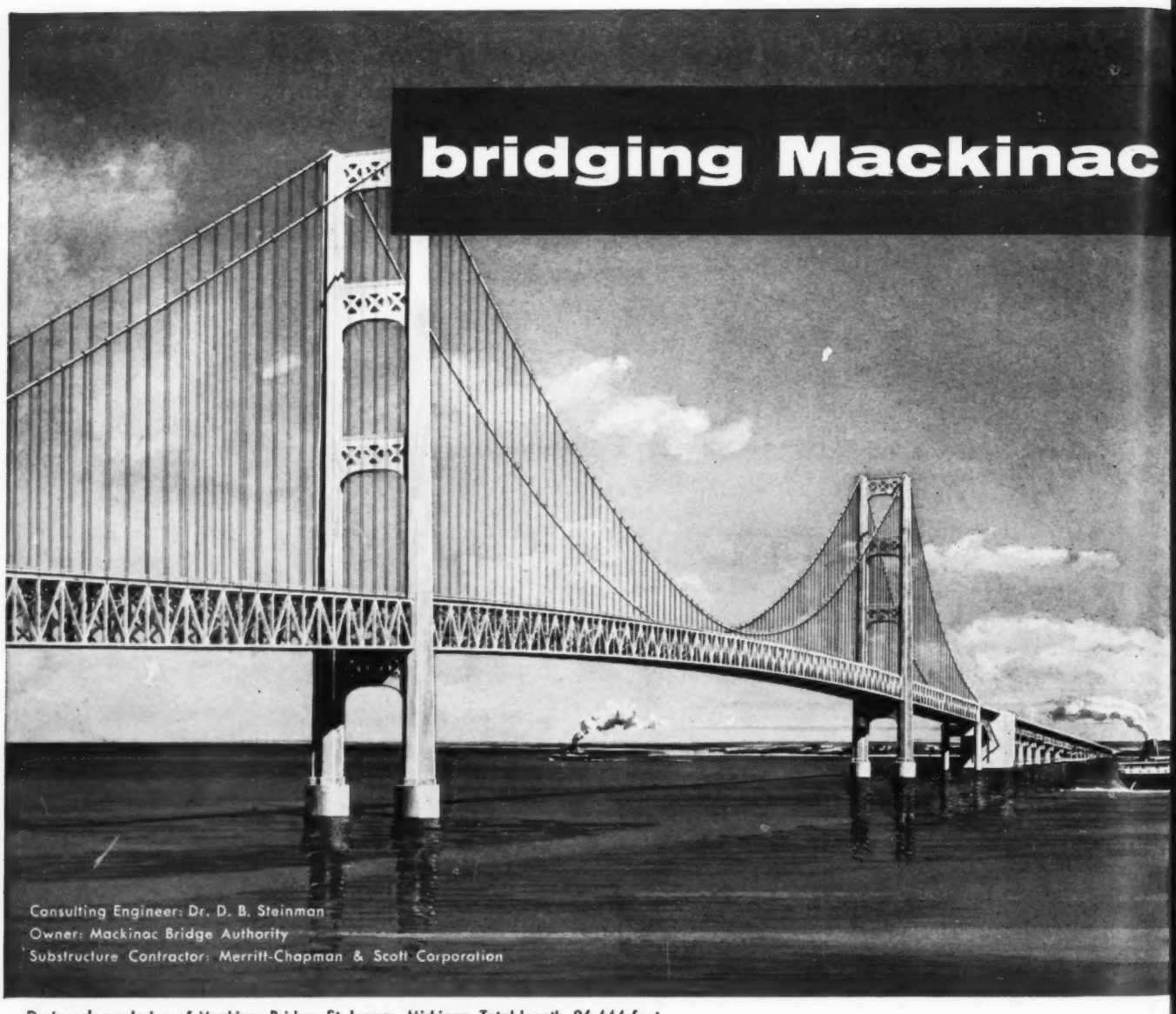
In some cases the analogies used were pretty mysterious to the non-judicial mind. While all judges agreed that there was nothing wrong in an individual laborer seeking to raise his wages through the process of individual bargaining with an employer, one judge compared the efforts of laborers to engage in collective bargaining to a prior case in which a man had scared away wild ducks from his neighbor's decoys by firing a gun in the air over his own land. Just exactly what the analogy is has never become very clear, except to a number of other judges who thought this sounded about right. They concluded that since the wild-duck scarer had committed a wrong, so had the laborers who attempted to organize for collective action.

Labor Regarded as Commodity

The principal analogy which evolved, however, was that the pitting of forces between labor and management over wages was basically the same as that which exists between the supplier and consumer of commodities which regulates the price of goods. In other words, labor was regarded as a "commodity" which the laborer supplied, and which was purchased by management.

This type of "struggle" is not in itself regarded as harmful but, to the contrary, is regarded as the essence of our competitive system. Thus, if a businessman tries to obtain the highest possible price for his product, this is considered beneficial to the community, rather than illegal. However, if he enters into arrangements with other businessmen to raise prices to an "artificial" level, or attempts to establish a monopoly which will permit him to raise prices unilaterally to an "artificial" level, this is illegal according to the common law. It is an "unreasonable restraint of trade." In a few cases, it has actually been held to be criminal, but normally it is simply regarded as a civil wrong or "tort."

Reasoning by analogy, the judges therefore concluded that, while individual bargaining by a laborer was good, collective bargaining was *per se* bad, because it attempts to raise labor "prices" to an "artificial" level. According to this analogy, it is not necessary to show any illegal or violent acts; the formation of the union is in itself illegal, just as a combination for the purpose of unreasonably restraining trade would be. The judges who held this way regarded the formation of a union as a criminal conspiracy and actually imprisoned a few people



Designer's rendering of Mackinac Bridge, St. Ignace, Michigan. Total length: 26,444 feet.

A great new link in our national highway system, the Mackinac Bridge, will soon span the Straits of Mackinac and connect the two peninsulas of Michigan. Scheduled for completion late in 1957, this suspension bridge—the world's longest from anchorage to anchorage—will rest entirely on Prepakt Concrete. Some 440,000 cubic yards are being placed for the 34 foundation piers.

Prepakt was selected for this five-mile project because of its greater—

Economy. Savings result from the use of a smaller, more economical plant which need mix only the Intrusion Mortar. Coarse aggregate, over 60% of the total concrete volume, is placed directly into cofferdams by self-unloading boats. For the same reason, supply problems are simplified and placement can continue uninterrupted during rough weather. Finally, Prepakt Concrete with less cement content is of better quality than tremied concrete.

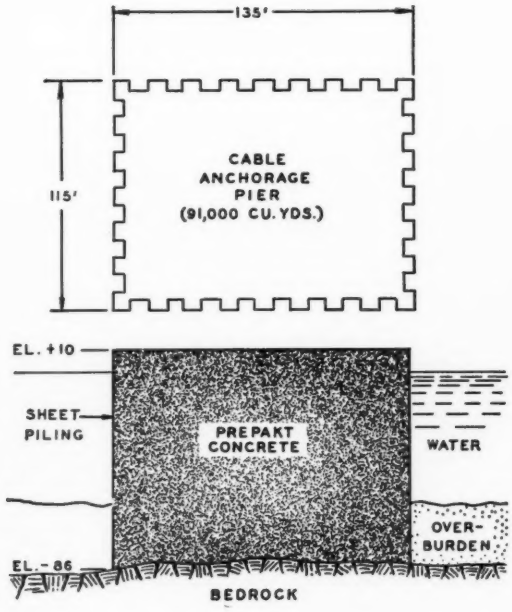
Speed. Rapid concrete placement by Prepakt's method has produced these new records for underwater placement from a single floating plant: 8-hour shift—1,800 cu. yds.; 24-hour day—5,040 cu. yds.; 5-day week—20,560 cu. yds.; 8-day period—28,320 cu. yds.

Flexibility. Prepakt Concrete does not require a continuous pour—placement can be halted and restarted on short notice at little added expense and with no sacrifice in quality. This proved a vital advantage during late 1954 when storms suspended operations repeatedly.

Mackinac Bridge will soon stand as another example of the multiple advantages of Prepakt methods and materials for all types of concrete structures. This $100-million bridge, believed for many years to be impractical if not impossible, is a tribute to its advanced design and the use of modern construction methods. A brochure describing the building of the Mackinac Bridge in greater detail is available upon request.

on Prepakt Concrete

Prepakt method cuts cost of piers, sets new concrete placement records

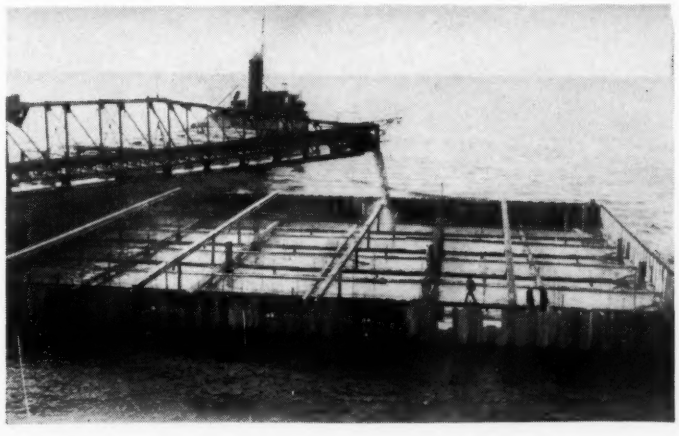


The 66,500-ton bridge superstructure is supported by 34 piers, some extending to more than 200 feet below the water surface. Concrete for these piers, made by Prepakt method of consolidating preplaced aggregate with Intrusion Mortar, was placed by the substructure contractor, Merritt-Chapman & Scott Corporation.

Almost all piers used cofferdams of interlocking sheet piling driven to bedrock. After removal of overburden, aggregate was then deposited into cofferdams from 10,000 to 15,000 ton self-unloading boats at rates up to 2,500 tons per hour. Final step was to consolidate stone with Intrusion Mortar which was batched, mixed and pumped from a Prepakt Floating Plant.

Use of the Prepakt technique introduced economies and kept the project on schedule despite the worst construction weather in many years.

Prepakt maintains a complete field construction organization plus an engineering service and functions as prime or subcontractor. For further information, write: The Prepakt Concrete Co., Room 779-Y, Union Commerce Building, Cleveland.



(Top) Unloading stone directly into cofferdam for massive cable anchorage pier. (Bottom) During concreting operations, Prepakt Floating Plant is tended by cement-Alfesil barge (left) and sand barge (right).

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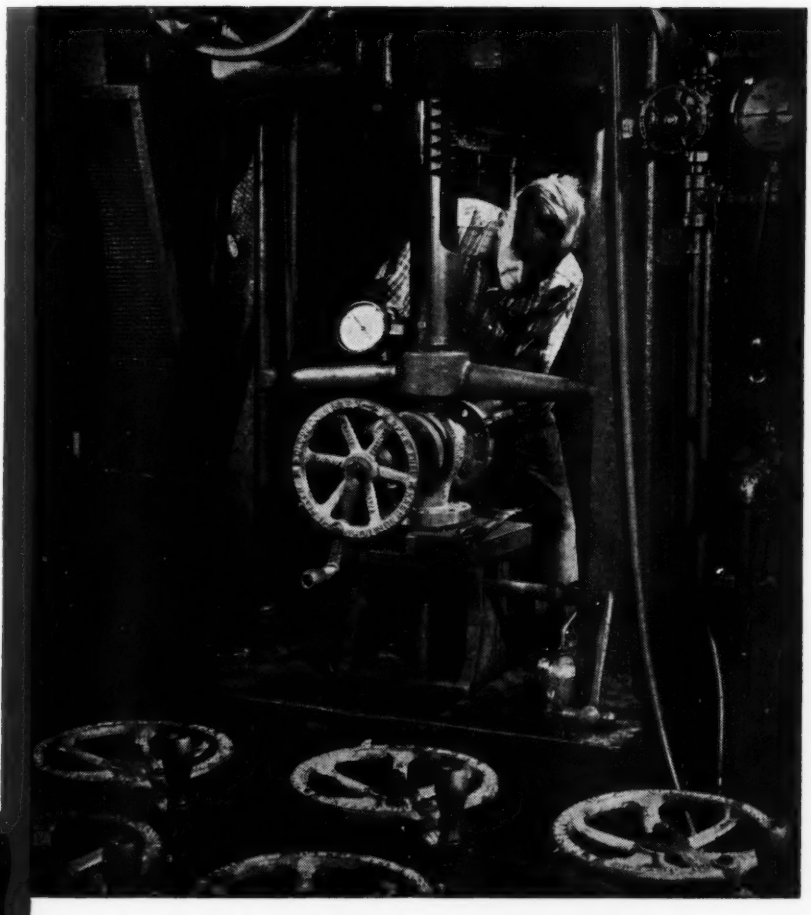
for an activity that is now regarded as perfectly normal, legal, and honorable.

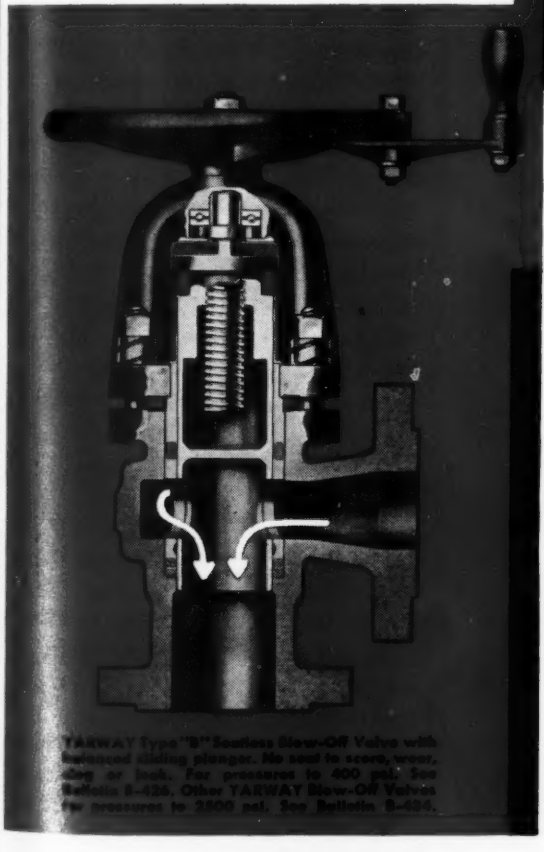
By about 1850, the idea that the formation of a labor union was criminal was just about dead. The law became settled that it is not a criminal conspiracy to do a lawful act (e.g. bargaining) in a lawful (i.e. nonviolent) way. This did not, however, mean that the judges changed their basic attitude toward labor unions, for instead of holding them to be criminally wrong, they retreated to the position that they were merely civilly wrong, i.e. tortious. For the next 50 years, the doctrine applied to labor unions was that of the *"prima facie tort,"* according to which doctrine the intentional infliction of harm on another is *prima facie a tort*, unless it can be shown to have been "justified." In the field of "economic pressure," justification was assumed to mean being a part of the normal competitive system. Since labor unions were not then "normal," their activities were generally regarded as unjustifiable and therefore tortious. The effort of labor unions to raise wages to "artificial" levels by collective bargaining therefore continued to be regarded as illegal.

The Injunction

The principal remedy obtained by management in the case of labor disputes was the injunction. The court enjoined the union from striking and from other collective actions that placed pressure on management. Since violation of the injunction was contempt of court, the labor leaders could still be put in jail despite the fact that their activities were not criminal. Furthermore, "temporary" injunctions were pretty freely given in advance of a hearing of the case, in order to "maintain the *status quo*." The result of such relief was to squelch many labor activities before they could get started in earnest.

This situation lasted about fifty years. By the beginning of the





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twentieth century, labor unions were no longer "abnormal," and "justification" for their activities was more readily found by the judges. To a considerable extent, the use of the *"prima facie tort"* in connection with management had declined, despite the relatively rough competitive tactics employed during this period; and, similarly, its use also declined in connection with labor cases. A number of dissenting opinions by Justice Holmes — in which he pointed out that the judges were not administering common law so much as their own view of economic principles — eventually helped to change the viewpoint of the courts.

Attitude Reverses

Whereas management was the "fair-haired boy" and labor the "whipping boy" before the turn of the century, the reverse attitude began to emerge by about 1890, when "trust-busting" became a new sport. The Sherman Anti-Trust Act of 1890 and the Clayton Act of 1914 were the first strong expressions by Congress of this attitude. These acts put teeth into the law of "unreasonable restraint of trade" insofar as management was concerned, but the Clayton Act specifically provided that labor was not to be regarded as a commodity, i.e. that the formation of labor "monopolies" was not illegal.

The change in view was rationalized largely by another analogy. Instead of regarding labor as a commodity supplied by the laborer and purchased by management, an opposite view was taken. It was pointed out that consumers could legally organize to put pressure on a businessman to lower his prices by refusing to buy from him. This is a primary boycott, which has always been regarded as legal under the common law. Labor unions were now regarded in an analogous light. It was said that they could organize to refuse to give their services to management, unless

management would meet their price. In other words, collective action for increased wages was regarded as basically a form of primary boycott, and therefore economically justified.

As a matter of fact, the newer analogy is not especially apt. The laborer is not buying anything; he is selling something. It is management who is in the position of the purchaser. But, since that gets the "wrong" result, we must turn the analogy upside down to get the "right" answer.

If we try to use the newer analogy mentioned, we are in the position of saying that the laborer "buys money" from management and "pays" for the money with his services. This is certainly a peculiar point of view, though not an impossible one.

Laborer as a Consumer

As a matter of fact, regardless of whether the laborer is a "buyer" or a "seller," the rules that govern him should be decided by the fact that he is a consumer of goods rather than a supplier of goods. The economic system is justified entirely and exclusively on the ground that it is for the benefit of the consumer of goods. Thus, as a matter of social expediency, it is more logical to treat the laborer as a consumer of goods than as a supplier of goods. This is essentially the rationale of the "newer" view of labor unions.

It should not be imagined that labor unions are exempt from the law by virtue of the fact that their kind of "competition" is now regarded as justifiable and therefore legal. For example, they are still responsible for the commission of illegal acts of violence. And, furthermore, there are limits beyond which "competition" is regarded as unlawful.

In the article which follows, it will be our object to examine the question of what activities of labor unions continue to remain unlawful. ▲▲

REPORT FROM ANKARA

FRITZ D. HIRSCHFELD
European Editor

THE LATE KEMAL ATATURK, the George Washington of modern Turkey, used all his influence in the period between the World Wars to introduce Western ideas to Turkey and to lift the country out of its centuries of Oriental lethargy. Many of Ataturk's dreams are now being realized.

The city of Ankara was personally selected by Ataturk as the proving ground for his Western concepts. He had wide, tree-lined boulevards laid out, public buildings designed that are as modern and efficient as can be found in any other world capital, and the people were taught to wear Western dress. The results as seen today are impressive and commendable in many ways.

But to modernize a country requires more than just a face-lifting for its capital city. Especially is this true in Turkey, where less than five years ago there were no central power plants or power distribution systems, where roads were little more than trails—dusty in the summer and muddy in the winter—where manufacturing was virtually nonexistent, and where almost no exploration for or exploitation of known mineral and other natural resources was being made. These are only rough yardsticks to measure the backwardness of the country and to point up the importance of any proposed modernization schemes.

American Consultants

American dollars being spent for dams, roads, power stations, and similar public and private works, always attract American consulting engineers. I visited a number of American interests already firmly established in Ankara; I heard about others who are actively sounding out the possibilities.

Knappen-Tippetts-Abbett & McCarthy are very active in the Middle East. The center of gravity of their operations is in Athens, Greece—where they maintain a major part of their engineering and design personnel because of the greater availability of trained local technical personnel in that area. Their assignments range from Greece to Lebanon. For the most part, this work is being sponsored by the local governments and includes dams, power plants, irrigation systems, and similar projects. KTAM is responsible for the complete design and construction supervision of what will be the largest earth-filled dam, in Turkey. When finished next year, the turbines will generate 36,000 kw (ultimate capacity of 54,000 kw), and there will be water for irrigation.

Charles Travis, KTAM's Middle East resident partner and one of the best-informed Americans in these parts, makes his headquarters in Ankara. Right up the street from KTAM, Morris-Knudsen maintains a small office. Byron Felkner is resident manager for M-K's Turkish projects. Presently, M-K is constructing the KTAM designed Seyham Dam. Future prospects include such items as six to ten NATO airfields, oil pipeline pumping stations, Navy NATO underground tank storage facilities, and a number of other big dam proposals in Turkey.

Grain Silos

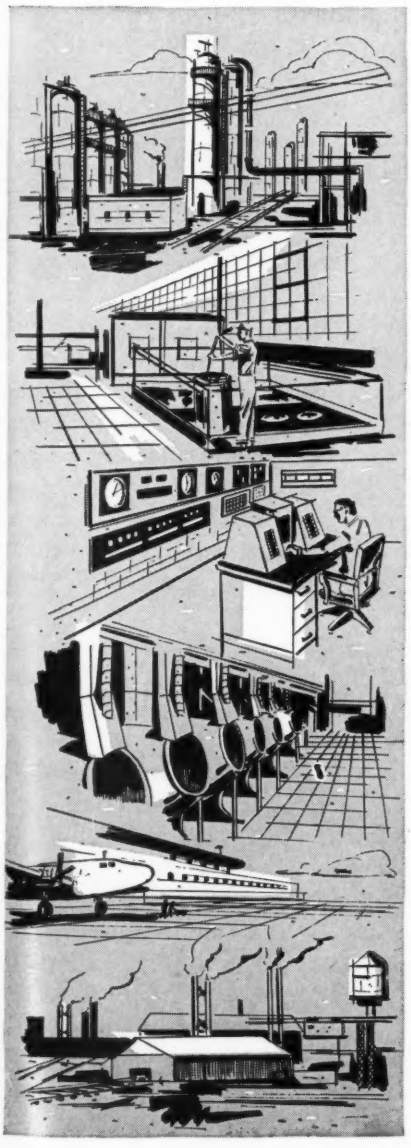
In the same residential area, where private houses appear to double as office space, the Raymond Concrete Pile Co. maintains an engineering staff. Alan Jacobs, European Manager of Raymond, is completing negotiations for a $12 million contract to build grain silos, with a gross storage capacity of approximately half-a-million tons, in key areas throughout Turkey.

According to Jacobs, the actual design and construction of these silos is fairly standard, but there is a tremendous planning and logistics problem involved because these silos are spread from one end of the country to the other. Individual contracts for each silo or group of silos will be drawn up in Ankara, and submitted for bids to the local Turkish contractors. The work will be managed, supervised, and inspected by Raymond. The Export-Import Bank and the Foreign Operations Administration are each underwriting half of the total costs. English and Danish contractors have been awarded additional contracts for the construction of central silos. The entire job is expected to take about 24 months to complete.

Turkey produces some 8 million tons of wheat annually—is the third largest wheat grower in the world. However, Turkish wheat has been difficult

A MESSAGE TO CONSULTING ENGINEERS

Have you noticed how frequently you're being asked for recommendations on DRYing? For example, if your specialty is one of these:



PETRO-CHEMICAL—Extreme DRYness is often required for the air, gases and organic liquids involved in processes . . . a moisture content of 3 to 4 parts per million, or less. Otherwise, reactions are likely to go wrong and product quality suffers.

METAL-WORKING—DRY controlled atmospheres are necessary in many heat-treating and sintering operations. Metals must be stored, parts inspected and assembled in DRY rooms to prevent corrosion. Costs are correspondingly lower.

POWER GENERATION—Pneumatic controls must be fed DRY air to prevent freeze-ups and clogging of delicate instrument ports. Control rooms are dehumidified to improve performance. The hydrogen that cools generators is kept DRY to safeguard their electrical insulation.

PHARMACEUTICAL—Areas in which hygroscopic materials are handled, whether they're tiny cubicles or complete workrooms, must be kept DRY. 10% relative humidity is common in industry. Precautions must be taken to prevent leakage of moisture into these areas and maintain this DRYness.

AIRCRAFT—Flight conditions at stratospheric heights in frost-free air must be simulated for airplanes, components and missiles. Wind tunnels and altitude test chambers must operate, therefore, at dewpoints below −100°F.

GENERAL INDUSTRY—Foodstuffs and jet engines have this in common: both are packaged in DRY inert atmospheres to prevent their deterioration. Wherever moisture is a hazard, it can probably be eliminated or held to a known, predictable constant. DRYing, then, becomes a matter of economics, balancing costs against gains.

Make someone in your organization an expert on DRYing . .

Be prepared for these requests when they come in. You select the man and we'll gladly assist in his education. Send us his name and we'll send him the book, *Because Moisture Isn't Pink,* and other data. Pittsburgh Lectrodryer Corporation, 357 32nd Street, Pittsburgh 30, Pennsylvania.

PITTSBURGH LECTRODRYER CORPORATION

to sell on the world market because of its poor condition resulting from exposure and long storage on the open ground. When the new grain silos are finished, this problem should be licked. Turkey's ability to export its wheat will undoubtedly prove a big boost to the economy.

Foster-Wheeler, under the able guidance of young "Skip" Elley, is responsible for building petroleum products lines and tank farms for the Turkish Ministry of Public Works. Foster-Wheeler is doing the engineering and inspection supervision of the overall project, worth about $40 million and paid for by NATO funds. With 65 to 100 American, local, and French people working for him (excluding field forces), Skip has the responsibility for one of the largest private American engineering enterprises in Turkey. Unfortunately, because most of the NATO pipeline work is classified, the details cannot be discussed at this time.

Highway Program

To find out something about the highway program in Turkey, I visited Ralph Agnew who is employed by the U.S. Bureau of Public Roads and was sent to Turkey to head up a mission (under FOS). He acts as a consultant to the embryonic Turkish Directorate of Highways. Originally a District Engineer for Colorado, Mr. Agnew and his predecessors here have actively aided the development of the country's road transportation system. The Turkish Directorate of Highways is now a going concern supervising the spending of approximately 6 percent, or $9 million, of the annual Turkish Government expenditures that go into road development; traffic has increased from 17,000 registered vehicles in 1947, to 70,000 vehicles registered at the end of 1954; about $25 million worth of heavy equipment is now maintaining better than 12,000 miles of all-weather road.

Agnew mentioned that the Chicago consulting firm of De Leuw, Cather was about to be awarded a $90,000 contract to make a traffic study in Istanbul. The size of the contract itself is probably not very important. Preliminary studies generally lead to positive measures.

A project very dear to the hearts of many Turks is a bridge across the Bosporus at Istanbul. The catch is to find the $150 million to build it. Agnew is not very optimistic that this proposal will ever materialize in his lifetime, but he does concede that if industrial progress continues at current rates, there may be real justification—and financing available—to actually build such a bridge.

Charles T. Main, Inc., of Boston, have been active in Turkey for a number of years. However, they have no Ankara office (that I could locate) and my only information is that their field engineers are busy supervising the construction of a Main-designed dam and hydro-electric power station near Ankara. Local shop talk has it that Ammann & Whitney, of New York, plan to open an Ankara office.

The Ralph M. Parsons Co., of Los Angeles, came to Turkey about four years ago to investigate the possibility of building a pipeline for the Turkish Government, and they have been here ever since. Their most recent project has been the design and construction of a 7000 barrels per day oil refinery in Eastern Turkey, which is expected to go on stream by late summer of this year. Parsons have also formed a Turkish Corporation to explore for natural gas. About $120,000 worth of drilling equipment has been imported, and they plan to start test drills very soon.

Before leaving Ankara, I met George Gibson, Chief Engineer of Parsons' Turkish operations. Mr. Gibson during his stay here has become a serious student of Turkey, its history, people, and problems. In the course of our conversations, I asked him what opportunities he could foresee for American consulting engineers in this country.

The short term outlook for Turkey, Gibson says, is bearish; long term it looks bullish. Turkey has spent a lot of money in its rush to industrialize. Its credit has become badly extended while at the same time its development schemes have either not been completed or have not yet reached a paying basis. The results are an inflated currency, difficulty in paying present obligations (which makes it harder to borrow further), and a condition demanding that precious dollar reserves be spent on vital imports.

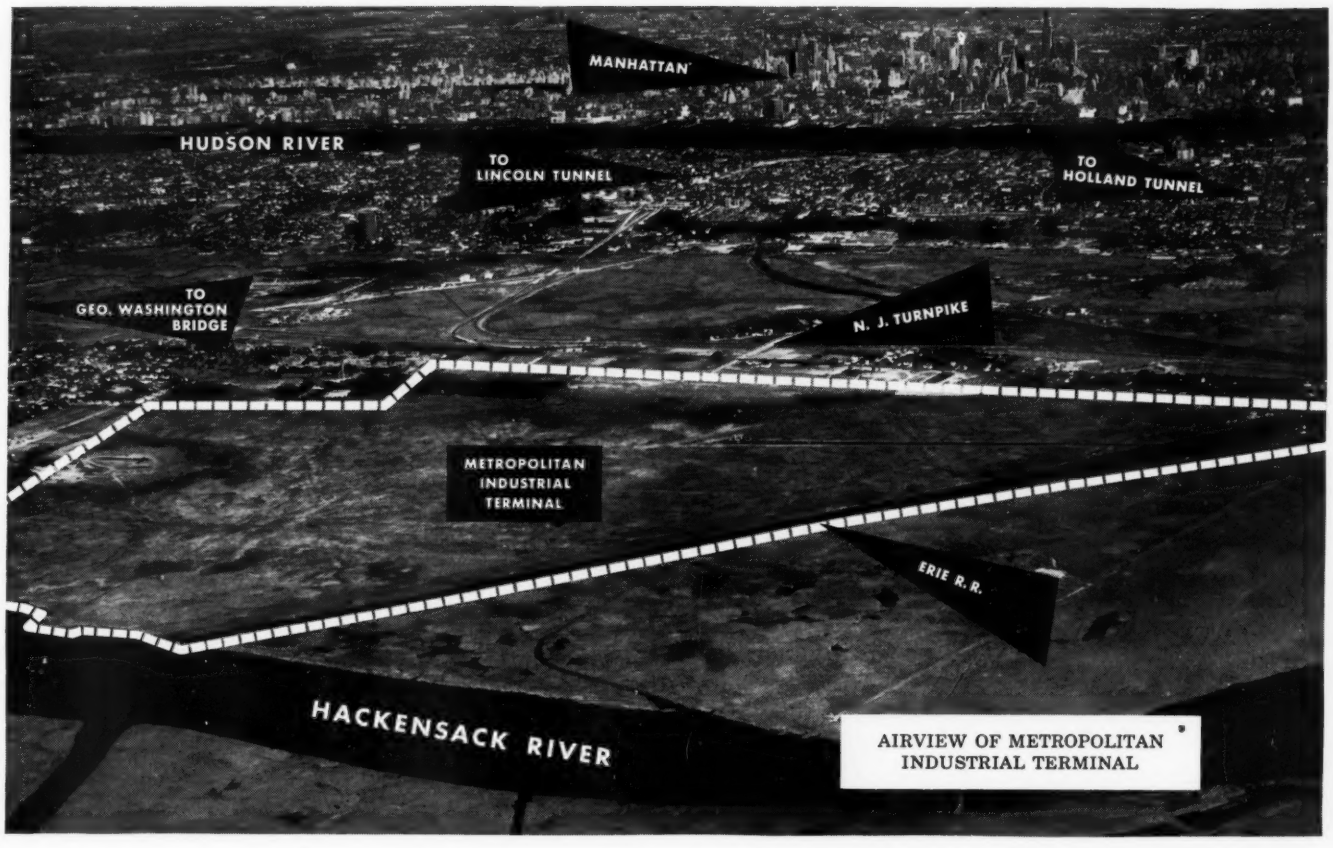
Picture Could Change

That picture could change very quickly. All the development projects in Turkey completed, currently in progress, or planned for the future, are aimed either at making the country self-sufficient or capable of exporting to earn dollars. Once dollars become available, the Turks have more than enough ideas for spending them.

In the meantime, U.S. aid to Turkey is continuing at the rate of roughly $75 million annually. Foreign firms are also investing capital to set up manufacturing plants here. Since the first of the year, the Minneapolis-Moline Co. has helped finance a Turkish company who will manufacture their farm tractors and implements in a plant on the outskirts of Ankara. Federal Trucks has made similar arrangements to manufacture its products locally. These investments will stimulate the establishment of local suppliers and distributors.

The Turks appear to have a deep appreciation for the help we are extending their country, not only in direct dollar aid, but in the attitude of the many Americans who have come over here to freely share their knowledge and experience for the benefit of Turkey. The fact that the Turks are receptive to our ideas and institutions will further brighten opportunities for Americans in this country. ▲▲

YOUR NEW PLANT WILL GROW IN THE ERIE AREA



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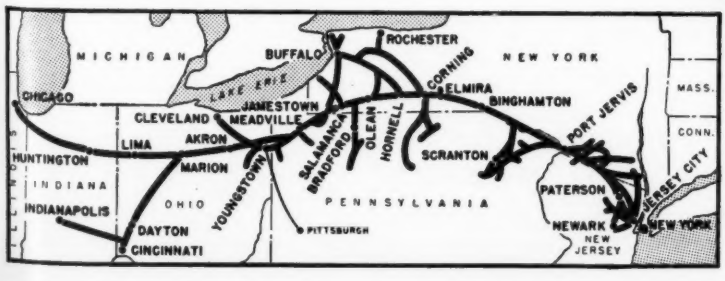

D. M. Lynn, *Assistant Vice President*
Industrial Development—Room 524-B, Erie Railroad
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ECONOMIC NEWS NOTES

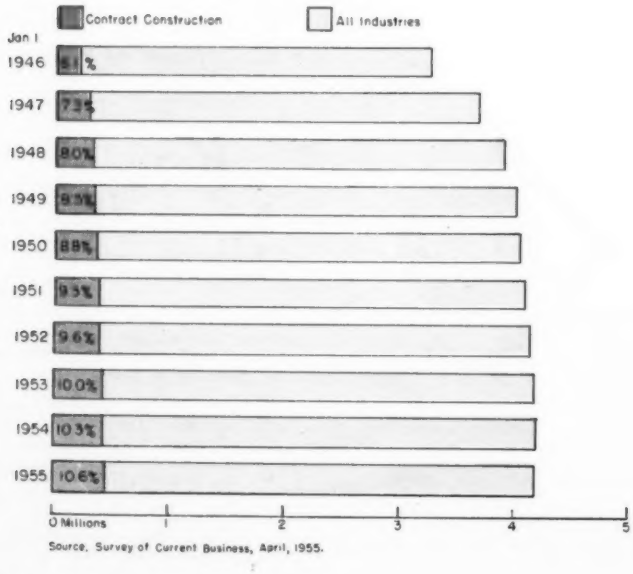
E. J. Mac Donald
INDUSTRIAL ECONOMIST

NEW VENTURE — Implementation of the Government's lease-purchase program for construction of Federal buildings got under way with the awarding of an architect-engineer contract for a branch post office in Scranton. Other architect-engineer contracts for post office buildings and courthouses are being awarded.

AREA DEVELOPMENT — A bi-monthly publication dealing with the problems arising in economic and industrial development programs has been started by the U. S. Dept. of Commerce. Area Development Bulletin will provide a central source of area information of considerable value to development groups. The first issue featured the objective of all development groups — providing new jobs and job stability. Available for 50 cents a year from U. S. Government Printing Office, Washington, D. C. or from Commerce field offices.

POPULAR BUSINESS — The most significant change in the business population last year was the rise in contract construction companies. The total number of business firms of all kinds, on the other hand, declined —the first drop in 10 years. As shown in the chart, the 443,300 contract construction firms in business at the outset of this year comprised 10.6% of all firms in operation. This percent has increased every year of the postwar period, rising from 6.1% at the close of World War II to 10.6% at the outset of this year.

CONTRACT CONSTRUCTION FIRMS
AS PERCENT OF ALL FIRMS IN OPERATION



Source, Survey of Current Business, April, 1955.

FALL PROSPECTS — Spending for capital equipment may provide the "soundest impetus" for fall business. In an analysis of the short-run business outlook, the First National City Bank refers to the recent McGraw-Hill survey that shows business is planning to increase capital outlays by at least 5% this year. Incidentally, if you are looking for an excellent analysis of business and economic conditions, you'll find it regularly in the Monthly Letter of this New York bank.

NO LET-UP — For every 10 super-markets now operating, three new ones will be built this year—three big ones, that is, with an annual volume of at least $1 million. This estimate comes from the recent annual convention of the Super Market Institute. With a sales gain of 15% last year and possibly better than that this year, super-market owners are doubling last year's construction rate. In addition to new construction, super-markets are modernizing rapidly. Over a third of the supers built in 1951 were remodeled between 1952 and 1954.

COAL PIPELINE — A $9-10 million pipeline will be built by Pittsburgh Consolidated Coal Co. to carry coal from its mines near Cadiz, Ohio, to a point near Cleveland. The pipeline will be able to move at least 1.2 million tons of coal annually in slurry form.

GOLDEN DECADE — Calling for an investment of $30 million in additional facilities at the Port of Charleston, former U. S. Senator (S.C.) C. E. Daniel put development of the port at the head of a list of "musts" drawn up for South Carolina's "forthcoming Golden Decade." He estimates that outlays of $2.5 billion will be called for in the state during the 10-year period by the industrial and population growth.

INTEREST CATCHERS — The land-saving motel in New Orleans built on stilts . . . . the striking auditorium at M.I.T. with its huge 1,500-ton concrete dome touching down at three points . . . . the transparent polyethylene "raincoat" that was wrapped around a Stanford, Conn., church during winter construction to prevent work interruptions and freezing of masonry . . . . the saddle-shaped State Fair Arena at Raleigh, N. C., with its vast exterior glass walls . . . . the world's largest pumping station on Lake Okeechobee, Florida, with six pumps that can each deliver over 500 million gallons a day—more than the daily consumption of the entire state . . . . the four-story circular concrete high school completed recently in Tokyo, with its pie-shaped classrooms and deck-like verandas . . . . the moving 82 in.-wide rubber sidewalk that carries 15,000 people an hour across a pedestrian bridge at the Coliseum in Houston. ▲▲

ATOMS IN ACTION

GENERAL WALTER BEDELL SMITH has been named chairman of the board and president of AMF Atomics Inc., the wholly-owned, newly-formed subsidiary of American Machine & Foundry Co. which will carry forward the company's broadening activities in the atomic energy field. According to Morehead Patterson, board chairman and president, "AMF plans to become the industrial department store for atomic energy equipment. In time, we hope to develop and supply equipment in virtually every aspect of the peaceful use of atomic energy. We are already in the forefront of constructing various nuclear reactors. We are also supplying handling equipment and control mechanisms for atomic energy installations. In the future we will increasingly devote our research and development efforts to applying nuclear energy in agriculture and in medical and related sciences."

TWO GENERAL ELECTRIC atomic experts, Dr. E. A. Luebke and L. B. Vandenberg of the Knolls Atomic Power Laboratory in Schenectady, have proposed an atomic reactor design that promises to remove obstacles to the use of atomic power plants in airplanes, locomotives and ships. Most of the weight and bulk of the conventional reactor is removed in the new design by "nesting" the reactor inside a cylindrical heat exchanger. Electric current for the pump to circulate the liquid sodium coolant is provided by generating an electric current in the heat exchanger by means of the temperature gradient normally existing between the hot and cold tubes, creating the necessary crossed magnetic field with iron pole pieces, and thus producing sufficient head on the liquid metal.

AEC ISSUED ITS FIRST REGULATIONS on April 15, under the licensing and regulatory provisions of the Atomic Energy act of 1954. The three regulations cover licensing of production and utilization facilities, special nuclear material, and safeguarding of restricted data. The regulation establishes two classes of facilities license: Class 103 and Class 104. Class 103 licenses pertain to facilities that may be determined by AEC to be of practical value for industrial or commercial purposes. Class 104 licenses cover facilities to be devoted to research and development or medical therapy. The catch is that the 103 licenses cannot be issued until the AEC determines that the type of facility in question has "practical value." Since AEC has not made any such determinations as yet, only Class 104 licenses can be issued for the time being.

WESTERN RESERVE university scientists recently reported that on the basis of animal experiments, properdin, a complex protein found in blood, gives protection against infection accompanying radiation sickness even when it is administered as late as five days after exposure to X-rays .... University of Michigan's professor Lloyd Brownell was quoted as saying that a radiation chamber big enough to process 14 tons of meat an hour could operate at a cost of 1/10c per pound .... American Machine & Foundry has completed preliminary designs for mobile crop irradiators to use radioisotope gamma radiation for destruction of insects in grain and prevention of sprouting in tubers such as potatoes .... General Dynamics Corp. has announced establishment of two 1-yr. fellowships at MIT, one in nuclear engineering and the other electronics. Each carries a stipend of up to $4000 .... Floyd Odlum, president of Atlas Corp., has predicted that the U. S. will have 40 million kw of nuclear power capacity by 1975, after which time practically all new plants will be nuclear fueled.

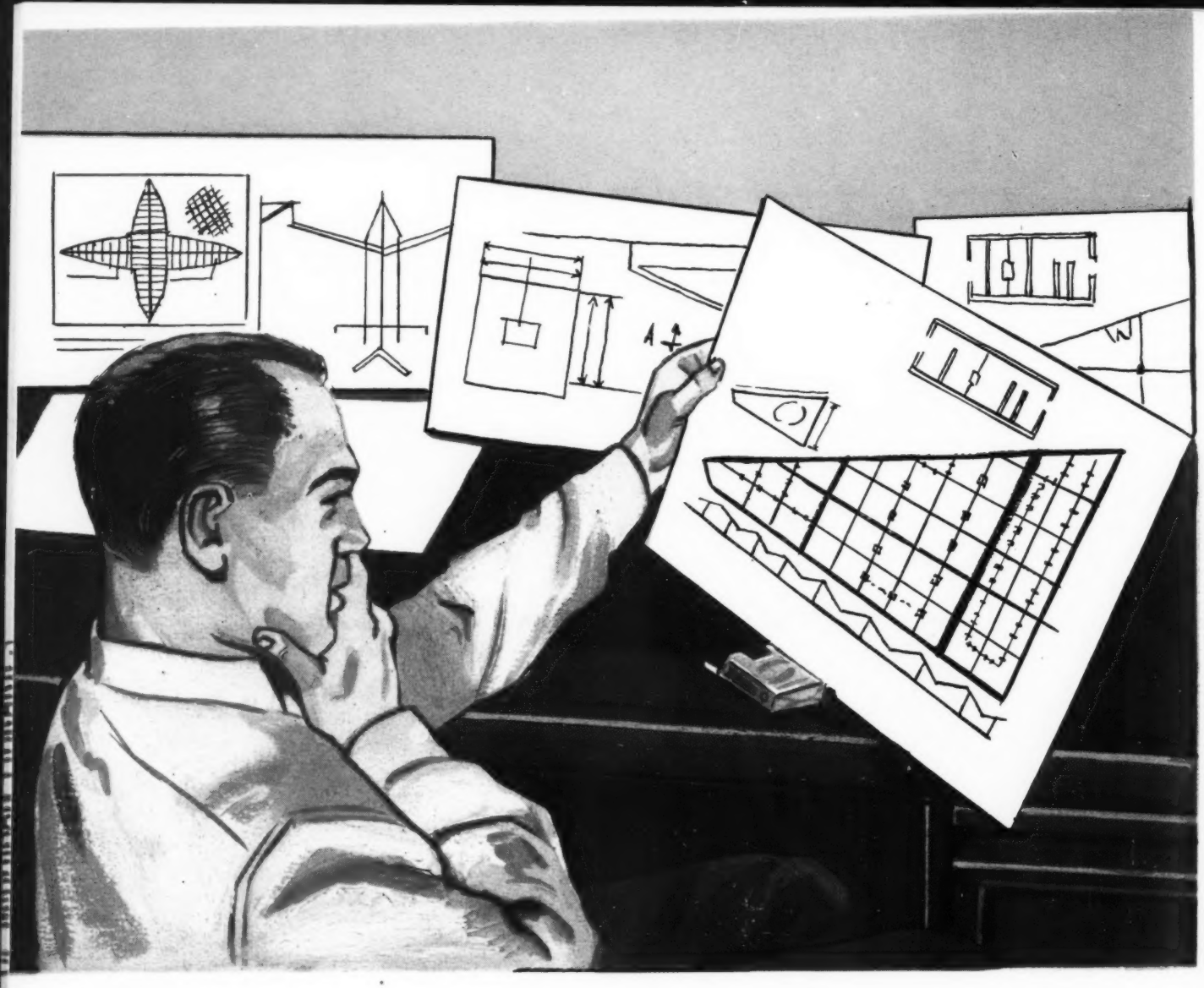
A REVISION OF AN EXISTING PATENT REGULATION and one new patent regulation have also been issued by AEC. The revision deals with rules under which people wishing to make a patent claim against AEC may do so. The new regulation sets up rules to be followed by people wishing to use patents that are either owned by AEC or owned by others but declared by AEC to be "affected with the public interest." However, this covers only AEC patents and patents AEC has already declared to be affected with the public interest at the time of application. It doesn't cover how an applicant should go about trying to get a license through AEC to use the patent not yet declared affected and it doesn't cover how AEC will go about making a public interest declaration or how the owner of such a patent can appeal such AEC ruling.

THE 23RD ANNUAL CONVENTION of the Edison Electric Institute, scheduled for Los Angeles June 13-16, will include a session on "Atomic Energy and the Electric Utilities." Speakers will be Lawrence R. Hafsted, director of the Atomic Energy Div. of Chase Manhattan Bank; Philip A. Fleger, board chairman of Duquesne Light Co.; Edgar H. Dixon, president of Middle South Utilities, Inc.; and J. Carlton Ward, Jr., president of Vitro Corporation of America.

THE NATIONAL ACADEMY OF SCIENCES will "undertake a broad appraisal of present knowledge about the effects of atomic radiation on living organisms and will seek to identify questions upon which further intensive research is urgently needed," according to president Detlev W. Bronk. The study will be financed by the Rockefeller Foundation.

SPEAKING AT the annual meeting of share holders in The Babcock & Wilcox Co., B&W president Alfred Iddles estimated that it will take ten years to determine the most economical and practical kinds of nuclear power reactors and that profits in the field will be low during this time. "But," he added, "we wouldn't be going into the business if we didn't think we would make money."

BONUS PAYMENTS to domestic uranium miners for initial production of uranium have passed the $5 million mark, according to AEC's Grand Junction, Col. office. ▲▲



How About Alternate Designs?

PAUL ROGERS
Paul Rogers Associates
Consulting Engineers

CE exclusive

IN PROPOSING to consulting engineers an architect-contractor-engineer relationship based on alternate designs, I realize that I am entering a controversial field. The proposed system is one in which the interested contractors submit to the client's architect alternate designs prepared by independent consulting engineers of the contractors' choice. There is considerable sincere divergence of opinion concerning the propriety of this procedure from the engineer's point of view. For one thing, the engineer is engaged by the contractor rather than by the client or architect. Many engineers object to this as well as other aspects of the system. I believe, however, that most objections are the result of lack of full understanding of the way the system would work and a failure to recognize the many advantages to the professional consulting engineer.

The medical doctor is not judged by the professional prestige of his client but on the basis of his own professional ability and his ethical standards. Similarly, being retained by a contractor does not in any way affect the professional standing of the consulting engineers involved.

European Experience

In the United States the use of the alternate design system has been largely confined to government projects, where it has not only been permitted but

occasionally encouraged. In many other parts of the world the method is an accepted practice, and some of our U. S. engineers who have done foreign work have seen the system and have noted the advantages.

There is reason to believe that Europe's impressive contribution to the development of new methods, systems, and patents in the field of structural engineering can be attributed to the adoption of this alternate design system. For example, reinforced concrete was not only invented in Europe, but it was developed there to a high degree of perfection before it was adopted in this country. Welded steel structures have been used in Europe for decades. Timber connectors, lamella roofs, thin shell designs, and prestressed concrete are further examples of structural engineering ideas that became well known in Europe before we took them up.

It would be a fallacy to assume that European engineers are technically superior to their American counterparts. Engineering education in this country is at a high level. There must be other reasons for the Europeans taking the lead in many new structural developments of importance.

One stereotype answer is that the low wages and high material costs abroad induce the construction industry to experiment with new material-saving systems, while designers can spend considerably more time on analysis than is practical here. To a certain degree, this is true, but this is only a small part of the answer. Competition, rather than cheap labor and a slow working pace, is the greatest stimulant to more efficient and economical solutions. Competition, strictly on an ethical and professional level is encouraged by the system of alternate designs.

The System in Operation

Let us now analyze how such a system would operate. Under the presently prevailing practice, architects, who usually hold the primary contract with the clients, employ or engage the services of structural engineers. They, in turn, produce a solution to the framing problem according to their best ability, and such designs are then incorporated in basic working plans and specifications. The disadvantages of this system are:

¶ Of the several possible solutions to the problem, only one is accepted and incorporated in the plans.

¶ Many architects are either not willing or not able to pay high enough fees to structural engineers to provide incentive to search long and intensively for the most economical solution.

¶ On some projects, the architect or his employees try to prepare the structural designs themselves which leads to handbook engineering at best.

¶ Nothing prevents part-time, mostly unregistered designers from preparing structural designs for the architect's signature, thus creating unfair competition for consulting engineers.

With the system of alternate designs, however, the architect would first make very preliminary working drawings. As far as structural design is concerned, only the proper clearances, loadings, and other specifications would be given. Each contractor interested in the job then would engage a competent engineer who would select what he considered the most efficient and economical solution and would prepare preliminary designs needed by the contractor to compute his estimates properly. The successful contractor then would have the structural engineer he had engaged cooperate with the architect in the final completion of working drawings and specifications for the project.

What are the limitations to such practices? It is obvious that every contractor bidding on a monumental suspension bridge could not employ a competent engineer and submit an individual design. Similarly, on major transportation, hydraulic, or sanitary works, where the consulting engineers are selected for their reputations, and where the preparation of plans may take many months, any alternate designs would be limited to certain special features or structures. But in industrial, power, commercial, and residential construction, such alternate designs are not only possible but highly desirable.

Advantages to All

In order to analyze the possible advantages of this system, we should consider individually the architect, the contractor, the client, and the structural engineer, noting the advantages to each.

The architect would benefit because he would not have to complete his working drawings in a great hurry. He would have greater latitude in artistic design, and he would not have to share his fee with the structural engineer. At the same time, he might retain his right to accept or reject the engineer's designs.

The contractor would be burdened with the additional cost of engineering fees for the preliminary designs, but such a system would permit him to compete not only on a labor and material basis, but would allow him to present entirely new ideas. Whereas one design might be based on conventional steel construction, others might offer welded rigid frames, or reinforced concrete, or cantilever design, or prestressed concrete, or other schemes, which only the competitive system can create. It is well known that contracting firms employ estimators who, as a rule, are very well paid, yet the cost of such estimators is not considered a waste. If all prospective contractors are requested to furnish their structural designs, no unfair advantage could be taken by any one of them under this plan.

The owner, after all, would pay for any additional expense resulting from several structural engineers doing preliminary work on the same problem. But there need not be additional expense. The fee to be paid for such services would be but a small part of the total cost, and it is not impossible that the archi-

tect's fees might be readjusted if the structural design is not included in their work. On the other hand, there is the possibility that improved designs might result in considerable savings for the owner, perhaps far in excess of the engineering fees.

The structural engineer should welcome such a scheme. It would free him from the rather inferior position he now frequently holds with relation to the architect on commercial and industrial building projects. It would permit him to indulge in unconventional designs; it would entice him to study improved methods and analyses; it would practically insure him that his ability will be rewarded. In competitive dealing, ability alone counts, and contractors would quickly learn about the engineers whose designs were known to be efficient and economical. Furthermore, such a system would be an inducement for the opening of many consulting engineering offices and increasing the proportion of engineers in private practice. Now our profession is largely an employee-occupation, in contrast to the medical and legal professions or the architects.

Ethical and Legal Aspects

Under this system there would be no substituting for already engaged engineers; there would be no fee-cutting and unfair competition; and all designs would be prepared by well qualified engineers.

Again, by specifying that only registered structural engineers be permitted to participate in the design of the competitive structures, there would be no violations of existing laws pertaining to the practice of architecture and structural engineering.

A system such as described would probably be opposed by some consulting engineers. Fears have been expressed that contractors would exert pressure on consulting engineers, pressure that might lead to a loss of dignity. It has also been argued that fee-cutting might be engaged in by the contractors, who are businessmen, and freely ignore professional ethics.

Surely, consulting engineers should, and do, have the ability and prestige to forestall any attempted subjugation by purely financial interests. In the prevailing practice abroad, engineers engaged by contracting firms enjoy the highest respect. Contracting firms, themselves, have been influential in promoting new engineering concepts — in promoting engineering prestige. It is very possible that the development of reinforced concrete construction would have been postponed by decades had it not been for the contracting firm of Waiss and Freitag, who bought up Monier's patents. Similarly, thin shell construction would not have been easily accepted if it had not been for the contracting firm of Dyckerhoff and Widmann, who encouraged the design of such structures and built them.

There is doubt that contractors would be more interested in cutting fees than in obtaining the most efficient and economical design. On the contrary, it is probable that the services of capable engineers with proven abilities would be much more sought after and would more likely receive the public applause they rightfully deserve.

It also has been argued that under the present system, architects and their engineers already do investigate the different possibilties before adopting a final system. Although such practice may be prevalent in some offices, there are many others where the pressure of time and limited fees makes this impracticable—and design competition is therefore lacking.

It is admitted that such practice would require a re-education of all parties concerned. It certainly would demand the cooperation of the architect, whose artistic designs would be influenced by the engineers alternate suggestions.

It is hoped that this proposal will be followed by sincere and thoughful discussion offering constructive criticism, which would be a benefit to the consulting engineering profession. While it is understood that this suggested system also has limitations and flaws, its many advantages recommend it. ▲▲

"WE TOLD HIM ROEBLING GOT THE JOB, BUT HE REFUSES TO GIVE UP."

Ground Rules For The Expert Witness

ROBIN BEACH
Consulting Engineer

Ce exclusive

TO SUSTAIN his dignity while testifying, the engineer-expert witness should be cognizant of the importance of the position he holds in court. On the witness stand he is the interpreter of science as it is variously expressed through engineering application, practice, development, and research. He alone, of the many witnesses, is conceded the privilege and the trust of the court in the application of specialized knowledge, particular intellectual capabilities, and specific experience for the purpose of piecing together the attested facts offered in evidence by lay witnesses. He is permitted to speculate and formulate a rational, tenable theory to explain how the incident basic to the case probably occurred.

This significant, and dignified objective of the expert's role in a trial should be consciously sustained in his own mind throughout the litigation. Predicated on this worthy objective, the desired behavior for an expert witness can be stated by listing pertinent attributes of his conduct.

The attire of the expert witness should be neat, conventional, and in good taste—as should be expected in any business gathering of ladies and gentlemen. This may sound elementary, but I have seen expert witnesses appear on the stand in an untidy state of attire, with unshined shoes, unpressed clothing, soiled shirts, and dishevelled hair. On one occasion the attorneys also appeared shoddy in appearance, court address, and presentation of their cases. These multiplications of careless preparation seemed to conspire against success in court. The trial was won by the opposing attorneys, who possessed characteristically superior talent as displayed by the meticulous care with which every feature of their part in the trial was prepared and executed.

Being considered a cultured gentleman himself, the engineer-expert should be courteous during his brief sojourn in court. He should remember that he is temporarily implanted in a strange environment. The customs, thinking, and terminology are not entirely familiar to him. His disciplined self-control and good manners may prove to be the common denominator by which he can keep himself on an even keel while in court.

While sitting on the witness stand, the engineer-expert should be especially careful not to distract attention from what is being said by fidgeting or squirming, by displaying nervousness, by unnecessarily handling or playing with papers in his lap or on the desk, by unconsciously doodling, or by engaging in other disturbing mannerisms. These distractions can be so disturbing that they will tend to antagonize the court.

The expert witness should maintain a relaxed posture during his appearance on the witness stand —in contrast to appearing taut, nervous, or unstrung. Particularly helpful is the relaxing control acquired by merely looking pleasantly at the jury members, the counselors, and others in the court-

room—thus dispelling self-consciousness, nervousness, and any outward signs of timidity.

In answering questions, the witness should never look down, as if abashed, nor should he look off and up into space, as if he were appearing to ponder or philosophize. Rather, he should always look at someone, such as the questioning attorney or the jury. The expert also should look at someone while explaining and clarifying difficult engineering principles.

He should never let opposing counsel visibly annoy, irritate, or anger him. By always maintaining a pleasant decorum in answering questions, the engineer instead may drive the questioning attorney to where he lets emotion rule.

Under Cross Examination

On cross examination, an expert may be confronted with a loud, insulting, abusive, or pugnacious attorney who obviously tries to intimidate and humiliate. In such a situation, after the attorney's attitude becomes increasingly apparent, the expert may address himself respectfully to the court, saying, for example, "Your Honor, as I understand my function here in court; it is to serve as interpreter of engineering and scientific principles and their applications for the clarification and understanding of the court and jury. As I am not accustomed to such an intimidating attitude of counsel in court, may I ask, Sir, if I am expected to submit to such indignity?" On one occasion, I did appeal directly to the court in this manner. The judge addressed himself to me, saying, "I wondered just how long you could continue to tolerate this abusiveness. May I assure you, there will be no more of it in this court." Whereupon the judge gave the counsellor a reprimand. It had a most stunning effect on the opposing attorney and aided our cause.

Occasionally, the cross-examining attorney may start a barrage of rapid-fire questions that is obviously intended to disconcert the expert into giving contradictory answers. Such a "barrage technique" in questioning may be effectively controlled and checked by never answering directly a rapid-fire question. The engineer-expert should put a stop to this style of questioning from the very start, perhaps by requesting a repetition of the question. The expert thus gains time to analyze the question carefully and to compose a thoughtful answer. If the question is deliberately repeated rapidly, he should request that it be repeated yet again and slowly.

The expert should retain control of the situation every moment he is on the stand. He unquestionably knows well his theory in the case and the principles of engineering and science that are basic to it. On the other hand, the cross-examining attorney can have only a slight acquaintnance with the technical aspects of the expert's theory. This he may have acquired by learning a few facts haphazardly through coaching and cramming. The attorney, it must be remembered, is an expert at interrogation. He has his "bag of tricks." But he is in no sense an expert on the scientific or technical theory basic to the litigation, even though he may have taken a special course on the subject (as a few renowned attorneys have done while preparing for some important trials).

If the expert witness has presented diagrams, shown various kinds of illustrations, operated mechanical models, or used displays of damaged parts while testifying, he may later find himself remarkably more at ease during cross examination by leaving the witness stand and returning to these visual aids. By being on his feet and walking about, the engineer can interject more showmanship into his testimony. He can address his answers more impressively to the court and jury.

During cross examination the expert should use great care, restraint, and discretion to avoid volunteering information beyond the expressed scope of the question. A garrulous witness may talk himself into great difficulty. Sometimes such difficulties arise through the suggestion of new and perhaps unanticipated lines of questioning or by introducing possibilities for contradiction of previous answers. If short answers are directed at the crux of the questions, the expert witness is much more likely to remember his answers and accurately recall them when the attorney refers to them later.

A lawyer who is an adroit master of questioning frequently can sway the novice expert witness into friendly agreement by asking leading question after leading question. A leading question is one so phrased that the answer is plainly suggested, as the attorney wishes it to be. For example, "Are you not working for Mr. G?" or "Have you not lived ten years with Mr. H?" Leading questions generally draw objections from the expert's counsel. Despite admonitions from the court, they continue to be commonly used—and all too often condoned. On cross examination more latitude is allowed on leading questions although their use is governed by the discretion of the court.

Expert Should Be Critical

The expert should be constantly on guard against agreeing, *carte blanche,* with leading or any other kind of questions on cross examinations. The expert should be critical of the accuracy inherent in such questions and of their intent. They should not be answered until they are corrected for improper phrasing, dual meaning, inaccurate terminology, or lack of technical clarity. Attorneys also are susceptible to being thrown off balance by the discernment of an expert in calling attention to the inaccuracy of facts used in phrasing questions.

In general, the expert should be ready to disagree with his inquisitor at every opportunity, doing this courteously and pleasantly but nevertheless firmly. Nothing should be conceded or acknowledged except

the hard, cold, proven facts in the case. By the manner in which an expert witness answers, argues, or parries the first few questions on cross examination, the attorneys in the courtroom can generally appraise the expert's potential abilities and experience on the witness stand.

Attorneys on cross examination sometimes become insistent that the expert answer a question "Yes" or "No." Relatively few questions relating to engineering can be so simply satisfied. The expert witness is entitled to clarify his answers by adequate explanations. He should resist all attempts to force from him an answer to any question that cannot be adequately satisfied by a "Yes" or "No" answer. The court will probably explain to the expert that he may answer with a "Yes" or "No," whichever more closely applies, followed by "with explanation." He may then explain the answer as fully as he considers necessary.

An expert should convey by his demeanor that he is, and wants to be, responsive in answering questions frankly and sincerely. He must not hedge against answering certain questions honestly and accurately when they are properly phrased, even though they are deliberately intended to reflect adversely against his side of the case.

False Evidence

It would be a calamitous error to show strong inclinations as an "advocate" of his principals—even to the point of bearing false evidence and testifying dishonorably. Such behavior is a treacherous discredit to anyone under oath but most particularly to an engineer whose chief stock in trade, aside from his professional ability, is his honor and integrity. He is liable to a jail sentence for perjury.

Strangely enough, the eyes of the court and counsellors all too often are closed to obvious perjury. Reluctance of opposing counsel to make issues of suspected perjury doubtless stems from their fear of offending the good will of the jurors by arousing pity for the witness. The jury may feel that the witness is being crucified in the interests of winning the case. (I know of quite a number of instances of perjury committed by lay witnesses. When an opposing expert witness once deliberately perjured himself, I did my best to induce my attorney to initiate immediate action against the witness—but this was all to no avail.)

If a cross-examining attorney poses questions that are quite remote from the theory under consideration, the engineer-expert might state that his experience in the specialized field is quite limited, but that he will answer the attorney's questions to the best of his knowledge. In event he is asked questions requiring computations, he should try to make the calculations as quickly as possible with reasonable precision. Then the expert should state that the answer, under the circumstances, is approximate. If the witness is sure of himself in making the calculations, he may impress the court and jury most favorably by stepping to the easel and performing his solution of the related equations on a large sheet of paper, explaining the simple meaning of the interesting parts of his mathematical operations as he proceeds.

On cross examination, the opposing attorney may question the witness regarding the number of court cases on which he has served, in an obvious attempt to discredit him as a professional expert witness. Generally, any derogatory implications can be dispelled by giving an average obtained by dividing the total number of cases in which the expert has appeared by the number of years back to his first case. The figure can be respectable even when the total number of cases is large. He may state, and indeed volunteer, that he has been a witness on behalf of defendants as well as plaintiffs.

An attorney on cross examination is quite likely to question the expert in detail about his witness fees in an obvious attempt to reveal how over-paid his services are, thus alienating him from the good graces of the jurors. The opposition may try to disclose special financial agreements that the expert may have with his principals, hoping to find some hidden derogation against the expert. A lawyer who indulges in this contemptuous behavior brands himself, rather than the expert, as being destitute of the finer artistry of his profession. However, the expert should answer the questions in a dignified manner, clearly and concisely emphasizing the fact that he is being paid for his time only.

Many eminent and highly qualified engineers and scientists have fallen from grace on the witness stand by being overly meticulous in splitting hairs. They go into unjustified detail on minutiae, and put the courtroom to sleep. An alert expert puts pep and zest into his answers, covering only the salient points, but making these clear, brief, and emphatic.

When the expert retires from the witness stand, he should leave the courtroom at once—unless directed otherwise by his attorney—to avoid being recalled to answer additional questions that may occur later to the cross-examining attorney. This also avoids the possibility of being accused of having material interest in the outcome of the case.

Quite commonly, the expert is invited to sit at his lawyer's table when his lawyer is cross-examining opposition witnesses. He can suggest penetrating questions for the lawyer to ask.

Qualities of The Witness

Anyone who voluntarily considers serving as an expert witness would do well to consider several important introspective points:

¶ Do you like debating with associates on technical or other subjects in which you are qualified? Under

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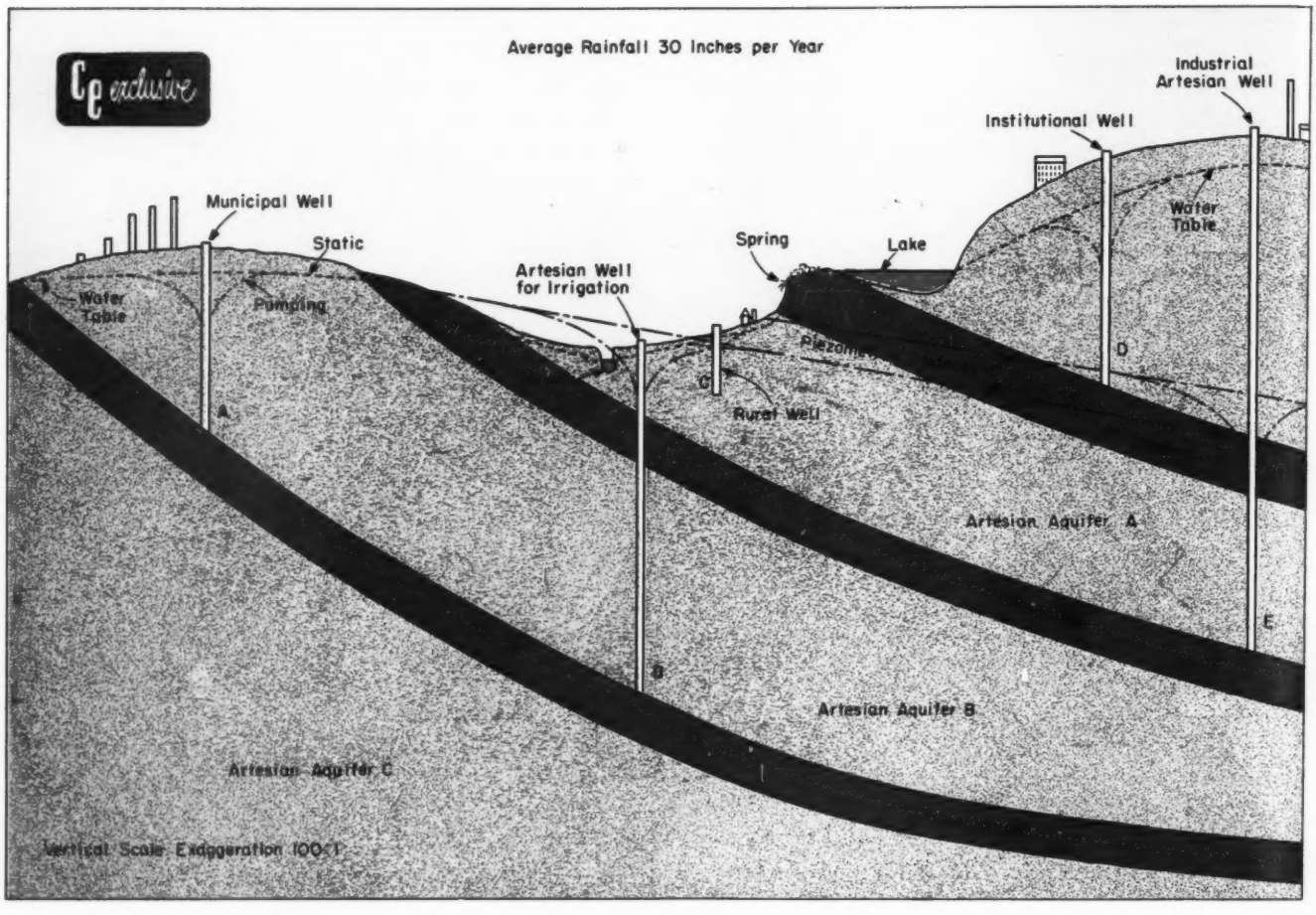

FIG. 1 — TYPICAL SECTION THROUGH WATER TABLE (UNCONFINED) AND ARTESIAN (CONFINED) AQUIFERS AND WELLS.

Solving Ground Water Problems

JOHN R. SNELL, Head, Department of Civil and Sanitary Engineering, Michigan State College

DURING the past two decades ground-water engineering has grown from an undependable rule of thumb approach to a highly accurate and practical science. New mathematical concepts, first employed in the oil drilling industry, are being adapted successfully to ground-water problems by an ever-increasing number of alert engineers.

With the trend toward decentralization of industry, each year ground-water systems must be developed for thousands of new plants. The large majority of institutions and the small to moderate-size municipalities also use ground water as their source of supply. On a national scale irrigation still uses more ground water than the combined demands of all other services, and annual consumption is growing rapidly. In a number of areas serious water shortages have become evident. This is especially true in parts of the great Southwest where periodically farmers must drill their wells deeper and lower their pumps.

In areas of limited recharge, the practice of mining water from subterranean storage cannot continue. Sound programs of resource management must replace present wasteful exploitation, but this can only be accomplished by better technical knowledge and wise legislation. Legal doctrines on the prior rights to use of surface waters are, in general, rather well defined. Laws governing ground water, however, are either few or nonexistent. This situation must be rectified soon, but a great deal of understanding and education will be required if such planning is to proceed wisely and fairly *(14, 35)*.

Annual rainfall in the United States ranges from less than 4 inches in the deserts of California and Nevada to over 140 inches in parts of Washington State. For the country as a whole the average is approximately 30 inches. Records show that of this total about 21.5 inches goes back into the atmosphere through evaporation from water and land surfaces and through transpiration from growing plants, and 7.5 inches runs into the ocean through rivers and

ground-water seepage. Only the remaining 1 inch, or 150 billion gallons per day, is used by man, with about 120 billion gallons a day of this total coming from surface waters. Ground-water sources supply the remaining 30 billion gallons per day, consumption being divided by use as follows: irrigation 18, industrial 6, municipal 3.5, and rural-domestic 2.5.

Ground-water supplies have numerous inherent advantages over surface-water supplies.

¶ For small or moderate-size systems the cost of development and operation is generally less.

¶ Ground water often is available in places remote from surface sources.

¶ It has a low, almost constant, annual temperature.

¶ Ground water's mineral content is rather constant (though higher than surface water), and it is free from suspended matter.

¶ There is less chance of contamination.

¶ Presently, there are fewer legal restrictions on the use of ground water.

¶ Large underground storage reduces the need for artificial storage.

Ground Water Hydrology

While the hydrology of ground water is much too complex to discuss in a few paragraphs, detailed information on this interesting subject is available in suggested references *(1, 3, 8, 9, 12, 13, 14, 15, 36)*. A number of fundamental concepts of water flow, however, are illustrated in Fig. 1, which shows a hypothetical geologic section with the vertical scale exaggerated about 100 to 1. As indicated, stream and lake surfaces often are intersections of the ground-water table, and in extended periods without rainfall, all stream flow originates from ground-water seepage. It should be noted that about 72 percent of the average rainfall is evaporated directly or through transpiration from living vegetation.

The terms aquiclude and aquifer are relative. Aquicludes are thought of as being nearly impervious and aquifers quite pervious. Wells A, C, and D are drawing from what are known as "water table" or unconfined aquifers, while wells B and E are artesian wells drawing from confined aquifers at two separate depths. An artesian well is a flowing well only if the piezometric grade line lies above the well mouth. The height of this piezometric level relative to the well is determined by the relative heights of the well and the recharge area, and by the resistance to the flow of the water in the artesian aquifer.

Water in both types of aquifers is never completely static but is moving in the direction of the slope of the piezometric surface. Under conditions of constant permeability and thickness, the flow is proportional to the slope of this hydraulic grade line. Some of the water flowing into a well comes from this perennial ground-water flow, but during the early stages (a week up to years), much of it comes from storage in the general area of the well.

Ground-Water Flow Into Wells

In developing the fundamental modern concepts of ground-water flow into wells, various formulas have been used in the past as contrasted to those recommended for application today. Fig. 2, showing cutaway sections of typical artesian and water table aquifers with one pumping and two observation wells in each, is a convenient reference for following this progression from the basic equation for ground-water flow under steady-state conditions ob-

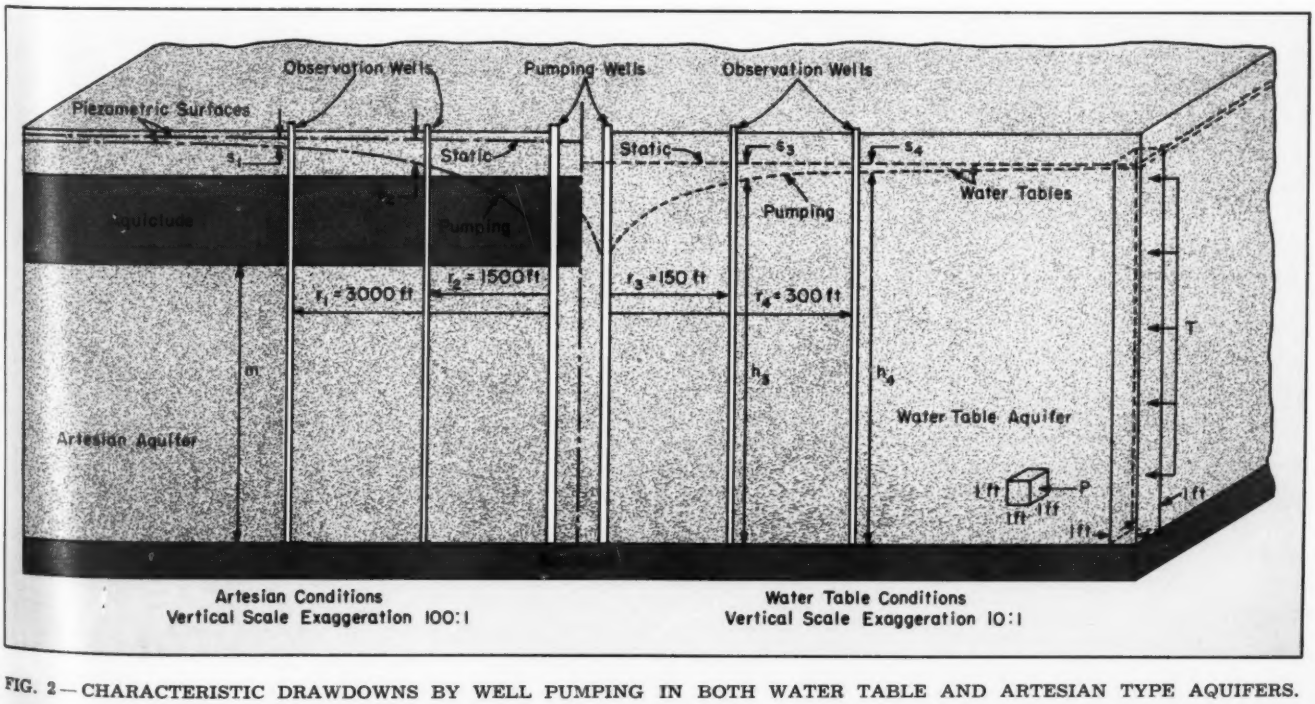

FIG. 2—CHARACTERISTIC DRAWDOWNS BY WELL PUMPING IN BOTH WATER TABLE AND ARTESIAN TYPE AQUIFERS.

tained from Darcy's law: $Q = PIA$; or $Q = TIW$.

Q = discharge in gallons per day (for above only). For all following formulas Q is in gpm.

P = Coefficient of permeability in gallons per day per sq ft under unit hydraulic gradient.

I = Hydraulic gradient in ft per ft (this is the slope of the piezometric surface).

A = Area of cross section in sq ft.

T = Coefficient of transmissibility in gallons per day per ft of width (of aquifer depth m) under unit hydraulic gradient.

W = Width of flow section in ft (which is m-ft deep).

The first application of this equation to wells, made by Dupuit, in 1863, was modified by Thiem in 1906. Omitting the derivation *(1)* a useful form of Thiem's equation for the water-table condition in Fig. 2 is:

$$T = \frac{527.7\ Q \log_{10} \frac{r_3}{r_4}}{h_3^2 - h_4^2} \qquad \text{Eq 1}$$

Under artesian conditions, or for water-table conditions where the drawdown, s, is small compared to the depth of the aquifer, the equation simplifies to:

$$T = \frac{527.7\ Q \log_{10} \frac{r_2}{r_1}}{s_2 - s_1} \qquad \text{Eq 2}$$

Where r and s are radius and drawdown at the respective observation wells. For these equations to apply the following conditions must be satisfied.

¶ The steady-state condition of flow must exist.

¶ The aquifer must be homogeneous, isotropic, and infinite in areal extent.

¶ The discharging well must penetrate and receive water from the entire thickness of the aquifer.

¶ The coefficient of transmissibilty T must be constant at all places and at all times.

¶ The flow lines must be radial.

¶ The flow must be purely laminar.

The most common error made in the use of these formulas is that the first limiting condition of "the existence of a steady-state" is either entirely neglected or is considered unimportant. Weeks, months, and often years of pumping at a constant rate may be required to fulfill this condition. If the results of short term pumping tests are used, the answers may be unsafe and may cause considerable embarrassment.

Modifications of the above equation often seen in water-supply textbooks are:

$$T = \frac{527.7\ Q \log_{10} \frac{R}{r_0}}{H^2 - h_0^2} \qquad \text{Eq 3}$$

$$Q = \frac{T(H^2 - h_0^2)}{527.7 \log_{10} \frac{R}{r_0}} \qquad \text{Eq 3a}$$

or for artesian conditions:

$$T = \frac{527.7\ Q \log_{10} \frac{R}{r_0}}{(s - s_0)} \qquad \text{Eq 4}$$

$$Q = \frac{T(s - s_0)}{527.7 \log_{10} \frac{R}{r_0}} \qquad \text{Eq 4a}$$

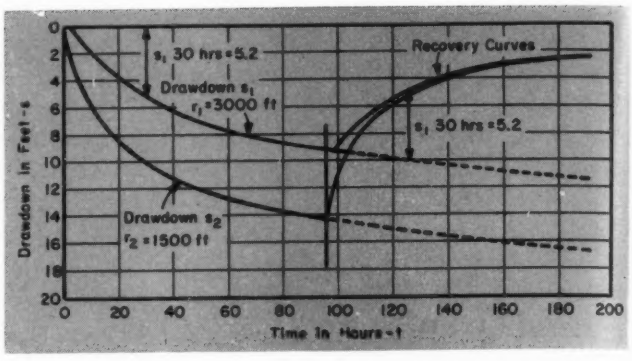

FIG. 3 — DRAWDOWN AND RECOVERY OF ARTESIAN WELL.

Errors in applying these equations are usually much more serious. Here, the pumped well with a radius r_o and a depth of flow h_o also is used as the only observation well, and it is assumed that at a mythical external radius R the water table or piezometric surface remains static. Thus, this equation is much more prone to give seriously unsafe results because the actual drawdown at the well face may be greatly increased over the estimated value by entrance losses and nonlaminar flow conditions. The assumption of an arbitrary value for R (given by various old-school authors as varying from 500 to 1000 feet) also leads to serious error, especially for artesian conditions where R often reaches out for miles. Thus, the steady-state condition assumed in the formulas is not apt to occur at R for many years.

Problems connected with the inadequacies of all of these steady-state equations were overcome by Theis in 1935 when he developed the nonequilibrium formula. This introduces two new factors, time t, and a coefficient of storage S. Theis' derivation *(29)* was based on an analogy between the flow of ground water and the flow of heat by conduction. In 1940, Jacob *(37)* published his derivation using hydraulic concepts directly, the equations generally being expressed *(1)* as follows:

$$s = \left[\frac{114.6\ Q}{T}\right] W(u) \qquad \text{Eq 5}$$

$$\frac{r^2}{t} = \left[\frac{T}{1.87S}\right] u \qquad \text{Eq 6}$$

where:

$$u = \frac{1.87\ r^2\ S}{Tt} \qquad \text{Eq 6a}$$

$$W(u) = \int_u^{\infty} \frac{e^{-u}}{u}\, du = -.577216 - \log_e u + u - \frac{u^2}{2 \cdot 2!} + \frac{u^3}{3 \cdot 3!} \cdots \qquad \text{Eq 7}$$

The term t represents time in days, and S is the storage coefficient expressed as a fraction.

For water-table conditions, S is equal to the volume of water that will drain freely by gravity from the void spaces of a unit volume of saturated aquifer. For artesian conditions the void spaces remain full of water, but with a lowering of the piezometric level the confined water expands in proportion to the light-

ening of the load and the modulus of elasticity. More load of the overburden is transferred to the aquifer's rock skeleton, causing it to compress slightly.

The coefficient of storage S for artesian conditions is defined as the relative amount of water released from storage in a unit vertical prism of the aquifer as the piezometric head declines one foot, and it is expressed as a decimal. For artesian conditions S is small, often about 0.001 to 0.0001, but for water table conditions S may be much larger—0.01 to 0.35.

At first inspection it would seem that this non-equilibrium formula is too complicated to be useful. However, the relationship between W(u)—called the well function of u—and u, although complex, has been worked out in tabular form *(1, 3, 4)*. When W(u) and the corresponding u values are plotted on log-log paper, they form what is known as a "type curve." This type curve is identical in shape to a log-log plot of s against corresponding values of r^2/t, and these data may be readily obtained from field observations when pumping an ideal well at a constant rate of flow, Q. Then by placing the "field data curve" over the "type curve" and matching them without rotating their axes a simple graphical solution is evident.

An illustrative example may clarify the method.

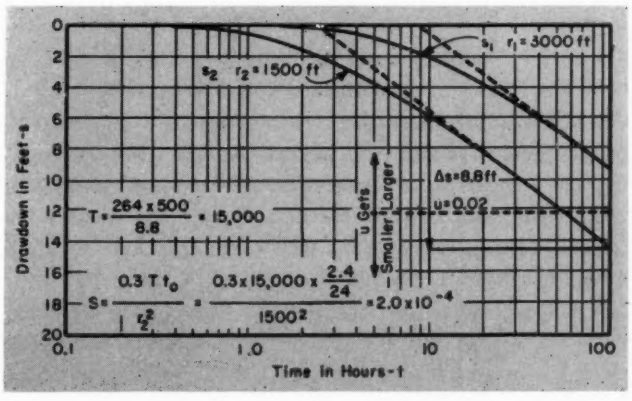

FIG. 5 — DRAWDOWN VS TIME FOR AN ARTESIAN WELL.

Assume an artesian condition similar to Fig. 2. After a period of recorded steady conditions in the observation wells and the pump well, the rate of pumping is suddenly changed and held constant at the new rate. Here it is increased from 0 to 500 gpm. Over a period of time drawdown values are measured in the pumping well and in one or more of the observation wells. Fig. 3 shows graphically the drawdown against time in representative observation wells that are 1500 and 3000 feet from the pumping well. It should be noted that the recovery curve is identical to the upside down drawdown curve and thereby provides a good check on the field work. From these data the values of r^2/t are calculated and plotted against s on log-log paper.

Fig. 4 shows this field data plot superimposed over the type curve. So that both curves can be matched and read conveniently at the same time, the field data plot is cut along the curve. In practice each curve is plotted on a separate sheet of transparent paper and one is superimposed over the other. An arbitrary match point is selected, and s and r^2/t are read from the field data curve, and the corresponding values of W (u) and u are read from the type curve, and the correspondshown: $s = 6.95$, $r^2/t = 4.0 \times 10^6$, $W(u) = 1.82$, and $u = 0.1$. Then, by substituting these values in equations 5 and 6 and solv-

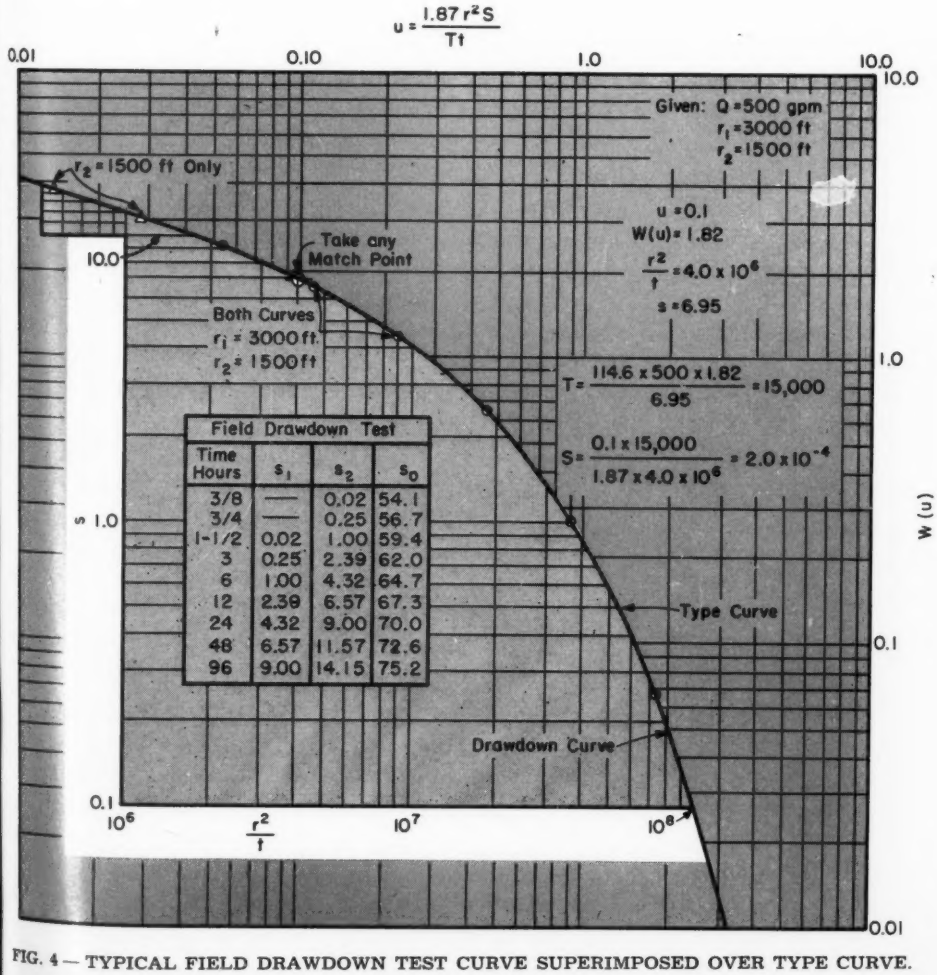

FIG. 4 — TYPICAL FIELD DRAWDOWN TEST CURVE SUPERIMPOSED OVER TYPE CURVE.

ing for T and S, the results T = 15,000 and S = 2.0×10^{-4} are obtained as indicated on Fig. 4.

With T and S determined for the aquifer tested, drawdowns may be predicted at any radius from the pumping well, for any flow, and at any time. Assuming that there is no entrance loss at the sandstone well face and that withdrawal from storage continues at the same constant pumping rate of 500 gpm, the drawdown at the end of 1 day, 10 days, 100 days, 1000 days, and 10,000 days can be computed. For the above values of T and S these respective drawdowns are: 70.0, 78.7, 87.7, 96.4, and 105.2 feet. (If the steady-state condition for equations 1 through 4 had been used, a predicted drawdown of ± 75 would have been estimated, and obviously, trouble in pump setting and discharge head would have been experienced.) If a number of observation wells are available, a single simultaneous drawdown reading for each well for time t after a change in the pumping rate Q would give data that could be similarly plotted on log-log paper and fitted to the type curve, solving for T and S.

A simplification of the general Theis nonequilibrium equation has been made by Jacob *(2)* as follows:

$$s_2 - s_1 = \frac{264\,Q}{T} \log_{10} \frac{t_2}{t_1} \qquad \text{Eq 8}$$

$$S = \frac{0.30\,Tt_1}{r_1^2} = \frac{0.30\,Tt_2}{r_2^2} \qquad \text{Eq 8a}$$

These equations, to be accurate, must be employed when u is less than 0.02. For artesian conditions this generally holds, but it may require rather long periods of pumping for water-table conditions. In any event, before employing equation 8, the u value can be calculated from $u = 1.87\ r^2S/Tt$. Equation 8, which plots as a straight line on semilog paper, comes from equation 7 by neglecting all but the first two terms in the exponential series.

Fig. 5 illustrates the plot of the data from the previous example. It will be noted that the plot is a straight line where u is less than 0.02. From this part of the curve, $s_2 - s_1$ is figured for a log cycle to be 8.8 feet. Since $\log_{10} t_2/t_1$ equals 1.0 for one log cycle, then from equation 8, $T = 264\ Q/8.8 = 15{,}000$. The intercept of this straight line with $s = 0$ is 2.4 hours $= t_0$. Thus, from equation 8a, $S = 2.0 \times 10^{-4}$.

Typical Problems and Solution References

¶ Interference between wells *(2, 28, 43)* is a common ground-water engineering problem. When a second well is placed near an existing well, the total water obtained from both wells is not doubled but is only increased slightly. The over-all drawdowns in the area are equal to the algebraic sum of the separate influences produced by each individual well pumped. The equation for the effect on an existing well of new wells r_1 and r_2 feet distant from the existing well is:

$$s = s_0 + s_1 + s_2 \qquad \text{Eq 9}$$

where: s_0 is the drawdown effect of the existing well on itself; s_1 is the drawdown effect on the existing well of the well r_1 feet away; and s_2 is the drawdown effect on the existing well of the well r_2 feet away. Correspondingly there are r_0, r_1, r_2, u_0, u_1, u_2, and appropriate W (u) values. Equation 9 is, of course, used in conjunction with equations 5 and 6.

¶ A geologic boundary, such as a stream or an impervious wall, is another factor that affects the yield of a well. Many of the problems associated with such circumstances, however, can be solved easily by employing the theory of image wells, which in effect makes a hydraulic analogy of the existing geologic condition. A stream, for example, can be replaced with a recharging image well equal in strength to the discharge Q of the real well. This image well is located equidistant from and opposite the stream from the real well. The image well reproduces the hydraulic requisite of no drawdown along the course of the stream. The distance to an invisible geologic boundary can be determined by a well pump test and three or more observation wells *(1, 2, 5,)*.

¶ The response of the water level in artesian wells to tides, passing trains, atmospheric-pressure changes, earthquakes, and to the tidal force of the moon or sun also is an extremely interesting subject. Accurate measurement of these phenomena sometimes can be used to advantage in determining T and S *(25, 26)*. Also the influence of these factors must be taken into consideration for accurate analysis of many ground-water problems.

¶ Exploration of an area for ground water *(16, 21)* also involves various problems. Most studies include: geologic reconnaissance of the area *(16)*; pumping tests on existing wells *(21)*; test drilling *(14, 16)*; and geophysical prospecting by seismic, gravity, magnetic, and electrical potential methods *(20)*. In addition, electrical resistivity has become a very useful tool in determining the nature and depth of subsoil conditions, and lately gamma ray measurements have proven to be a useful tool *(42)*.

¶ Two equations are used for calculating the time it takes for a drop of river water, or a drop of water in space, to reach a well *(2)*. These are as follows:

$$t = \frac{m\,\theta\,a^2}{91.8Q} \qquad \text{Eq 10}$$

$$t = \frac{m\,\theta\,r^2}{61.25Q} \qquad \text{Eq 11}$$

where: a = distance in feet to river, Q = discharge in gpm, t = time in days, m = thickness of aquifer in feet, r = distance traversed in feet, and θ = porosity. The time for a drop of water to move a 1000 feet into an average well is about 5 to 10 years.

¶ The percent of well water k originating from a river *(32)* is obtained by solving the following formula:

$$k = \frac{1.87\,a^2 s}{Tt} \qquad \text{Eq 12}$$

This equation is useful in predicting the expected change in temperature and chemical analysis in a well after it has reached equilibrium with the river.

¶ Many other types of ground-water problems will become evident from a review of the bibliography. Of particular interest is the fact that the more complicated problems can be solved accurately and rather painlessly by construction of analog models described by Muskat *(9,* pp. 561-617). The reader also is invited to study further this new engineering science, for he is certain to find ground-water hydrology extremely interesting, and if the study is taken seriously, perhaps quite profitable. ▲▲

Acknowledgment is made to John G. Ferris of the U.S. Geological Survey for his helpful suggestions and assistance in selection of reference material.

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LEFT TO RIGHT—SEATED, F. A. RITCHINGS, CHIEF MECHANICAL ENGINEER; W. H. COLQUHOUN, ENGINEERING MANAGER; W. T. ROGERS, SAFETY DIRECTOR; E. K. WILKINS, GENERAL CONSTRUCTION MANAGER — STANDING, E. S. CROCKETT, ASSISTANT CONSTRUCTION MANAGER; H. L. LOWE, CHIEF ELECTRICAL ENGINEER DISCUSS THE SAFETY FEATURES OF DESIGN ON AN EBASCO PROJECT.

Make Safety an Integral Part of Design

W. T. ROGERS, Safety Director, Ebasco Services Incorporated

William T. Rogers received his E.E. degree from Polytechnic Institute of Brooklyn, in 1927, and his M.B.A. degree from the Graduate School of Business Administration, New York University, in 1935. He also completed graduate study in Economics and Finance at Columbia University.

His professional experience includes service with various divisions of Consolidated Edison Company, where he started as Assistant Engineer and subsequently held positions as Engineer on staff of General Superintendent, Safety Engineer, Economist on staff of Vice President, and Assistant on staff of Controller for property valuation studies. During this time he organized and directed personnel department functions including: employment, safety, medical, employees' welfare, job classifications, and employee services.

In 1936 he joined the statistical budget and insurance department of Ebasco Services Inc. and later served as Industrial Relations Consultant. He developed the safety and fire protection activities in the insurance department, which became the basis for the present safety services. Currently he is Safety Director, in charge of Safety, Health, and Accident Prevention Administration services for a large group of electric, gas, and industrial clients in the U.S. and abroad, and of the Safety Programs for all Ebasco construction projects. Mr. Rogers also is Managing Director of the Inter-American Safety Council.

THE INCREASING TEMPO of modern living greatly accentuates the importance of safety. New hazards are being created as fast as, if not faster than, safety measures can be taken to reduce or eliminate them. Accidents now account for nearly 100,000 deaths and over 9,000,000 personal injuries each year. As the population and the industrial growth of the country continues, intensive safety programs are necessary not only to reduce but to prevent increases in this terrific accident toll.

Safe operation of facilities and education of people to avoid unsafe acts can do much to reduce the number and severity of accidents. However, the consulting engineer and designer can influence the accident picture greatly by making safety an integral part of his designs. This applies not only to de-

sign of tools, machinery, equipment, and consumer products, but to the more frequent concern of consultants—buildings, plants, and facilities.

At Ebasco, one primary objective is to "stop accidents on the drawing board." While approximately 90 percent of all accidents are the result of human failure, we can prevent a large proportion of these human failure accidents by making both the building and the equipment as foolproof as possible. Our goal, though it may not be completely attainable, is *to make it impossible to get hurt.*

There are many important reasons why we incorporate safety into our designs. Obviously, the completed building, plant, or facility must meet all local, state, and insurance requirements with respect to safety and fire protection. We also must be sure that the completed work will be safe structurally, will be safe to operate and maintain, and will not create any safety or health hazard for the public. But additionally, we find that a plant or building designed for maximum safety facilitates work flow, provides better storage and housekeeping facilities and usually is more efficient in other ways.

Many of our projects have proved that a safe structure is more economical, if not to build, to operate and maintain. When safety is given advance consideration, there are fewer changes during construction. Subsequent modifications to meet operating or maintenance requirements are reduced. Very often the resulting structure or plant can be operated by a smaller working force. This naturally decreases the accident potential through reduced exposure of the personnel.

While economics play a large part in engineering, it should be stressed that safety in design cannot be evaluated on the basis of initial investment alone. It is true that construction with minimum space, equipment, and materials will bring about a lower cost. But expenses such as: shutdowns caused by fire or failure of adjacent equipment; higher maintenance costs brought on by the necessity for elaborate, time-consuming barricading, blocking out, and slower work because of cramped conditions; and direct or indirect costs of accelerated employee injury rates, will more than wipe out initial savings.

Incorporating Safety in Designs

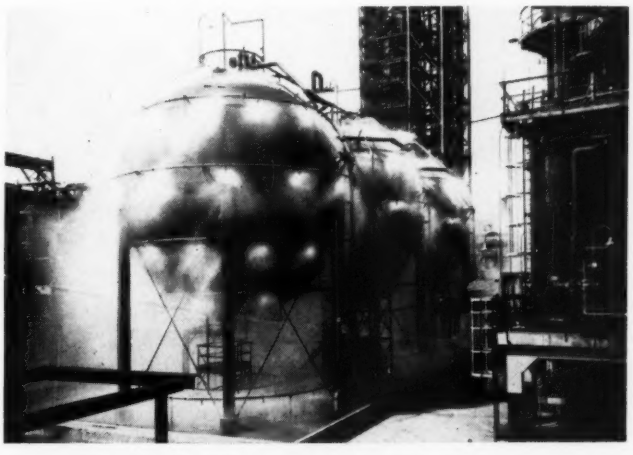
There are many sources of accident prevention material and assistance available, applicable to engineering design, that help consultants in working out safety problems. Each state has certain safety codes that should be consulted during both design and construction. The American Standards Association has practical and reasonable safety codes that should be followed. Loss prevention engineers of insurance companies, various local safety councils, Underwriters Laboratories, state safety representatives, safety consultants, and safety divisions of the various trade associations all may be called upon for assistance. The local city government at the project site also may have specific safety codes, and these must not be overlooked.

A consultant also must ascertain that his fire protection design conforms to the local underwriters' requirements. His prestige can suffer if he incurs fire insurance rate penalties for his client by installing specific equipment improperly; using unapproved construction materials; failing to include required fire walls, sprinklers, or approved electrical fixtures; or allowing other hazardous conditions to exist during any phase of his projects.

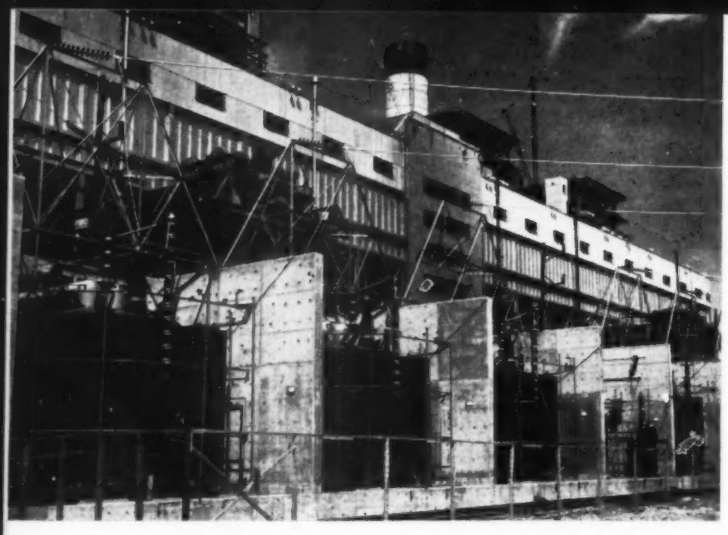
At Ebasco, safety and fire protection details begin even before the project reaches the drawing board. Factors, such as location, type of operation, possible future developments, and other contingencies, are all considered from the safety standpoint when the design is initially conceived in the mind of the engineer. When the project reaches the drawing board stage, every possible attention is given to designing a safe structure. If a design engineer is confronted with a technical safety design problem on which he needs help, he consults with the Safety Director and his staff. The design engineers also submit prints to the Safety Director and his staff in the early stages of design for review and recommendations relative to the incorporation of safety features. Fire protection engineers check the prints to eliminate pitfalls of this nature.

Typical Safety Features

Obviously, it would be impossible to attempt to enumerate all of the safety features that can be incorporated in the design of various structures. A complete list could never be made because one feature leads to another. New process developments and building construction concepts are continually creating new hazards that must be solved. However, the following items illustrate the type of thinking



WATER FOG SYSTEM ON HORTONSPHERES CONTAINING LIQUEFIED PETROLEUM IN THE HEART OF A REFINERY. NOTE CAGES ON LADDERS, KICKPLATES ON PLATFORMS, RAILINGS, AND LIGHTING SYSTEM.



TRANSFORMER FIRE BARRIER WALLS AT A POWER PLANT. NOTE AUTOMATIC FOG SPRAY EQUIPMENT IN EACH COMPARTMENT AND TEMPORARY PROTECTIVE FENCE INSTALLED DURING CONSTRUCTION OF PLANT.

that will result in a safe job. Other items will be evident to those consultants, architects, and designers who automatically seek perfection in creating a safe structure, plant, or facility.

¶ Provide adequate lighting.
¶ Have light switches conveniently located.
¶ Isolate electrical equipment.
¶ Separate hazardous operations.
¶ Be sure all of the electrical wiring is adequate to avoid overloading.
¶ Include crank operated windows (with adequate operating space) that can be cleaned from inside.
¶ Place extra grab bars in tubs and showers.
¶ Use color to promote safety.
¶ Design for easy flow of goods and materials.
¶ Plan for easy flow of pedestrian traffic.
¶ Facilitate entrance and exit.
¶ Consider possible emergency conditions.
¶ Arrange drives and parking areas for safe motor vehicle travel.
¶ Put radiant heating coils under sidewalks and drives where necessary to prevent slipping in freezing weather.
¶ Eliminate through traffic streets.
¶ Install ramps where possible in place of steps.
¶ Use nonslip floor construction.
¶ Furnish good housekeeping facilities.
¶ Supply proper water and fire protection systems.

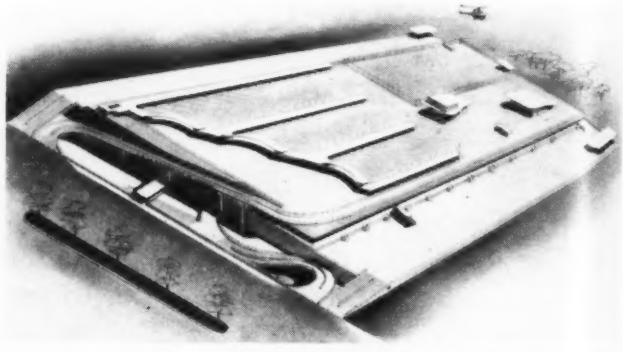
In designing power plants and electrical substations the consultant must visualize the operation of the equipment under normal and abnormal conditions. It must be borne in mind that in an emergency a man will do what comes easiest and most naturally. When falling he will reach out to save himself and may make electrical or physical contact. We find these procedures helpful in avoiding such contingencies:

¶ Visualize movement of operators, maintenance men, cleaners, and inspectors.
¶ Design in units, cells, or compartments to prevent the spread of trouble.
¶ Place all similar equipment in each "block" in the same sequence so that operating procedure can be repetitious.
¶ Provide ample space with good lighting.
¶ Have good head room, elbow room, good choice of equipment, clean cut arrangements, and positive identification of circuits.
¶ Locate transformers, buses, and other electrical equipment so men cannot contact live parts.
¶ Protect against "low voltage hazards."
¶ Eliminate explosion hazards. In coal burning plants, install ample ventilation systems for the conveyor rooms, and avoid pockets where coal gas or coal dust could collect. In the turbine generator area arrange the pedestal and structure to prevent hydrogen accumulation.
¶ Furnish suitable guards and barriers around rotating or dangerous equipment.
¶ Avoid blind alleys and dead ends.
¶ Use visible edge safety tread grating on stairs.
¶ Watch out for tripping hazards, such as obstructions and floor openings.
¶ Install adequate railings and toe boards.
¶ Supply platforms and ladders for easy access to valves, instruments, and bearings.
¶ Specify aircraft warning lights on high structures even though not required by CAA regulations—just as an additional safety precaution.

Many of these suggestions will apply whether the project is a generating station, gas plant or booster station, paper mill, or any other industrial structure or facility.

Safety in Construction

When the engineering and designing is finished, we get into safety in construction. However, before construction begins, we have another important duty to perform. We must see that safety is written into the construction contracts and specifications. Every serious accident on the job, especially a fatality, causes adverse publicity to the job, the client, the contractor, and the consulting engineer. This ad-



SAFE PARKING AREA ON ROOF OF A BUILDING FOR AUTOMOBILES AND HELICOPTERS. NOTE CENTER BARRIERS ON RAMPS AND THE SAFE WALKWAYS FOR PEDESTRIAN TRAVEL UNDER PROTECTED SHELTERS.

verse publicity is definitely not wanted by the client because usually it is directed primarily at him. Thus, it is good business for a consulting engineer to want his safely designed job constructed safely.

One way the consulting engineer can play an important part in seeing that his project will be safely constructed is to include safety clauses in the contract he submits to his client for approval. These clauses are important in the event that the low-bidding contractor does not assign accident-prevention minded supervision to the job. Most contractor managements want safe jobs, but for the few exceptions, these safety clauses are helpful to both the project manager and consulting engineer. These safety clauses in a contract also show the client that the consultant is accident-prevention minded.

Ebasco's Safety Contract

Listed below are a few excerpts from one of Ebasco's contracts. These provisions definitely put the project manager in charge of the safety of operations, not only of his own men but of the contractor's men as well.

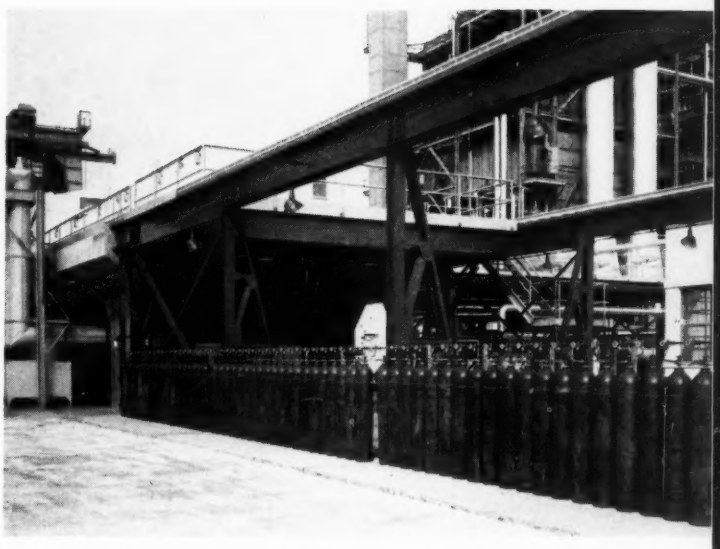
"The Engineer shall have the right to direct the manner in which all work under this Contract shall be conducted insofar as may be necessary to secure the safe and proper progress and the specified quality of the work, and all work shall be done and all material shall be furnished to the satisfaction and approval of the Engineer. . ."

"The Contractor declares that he has familiarized himself with all federal, state, and local laws and regulations enacted for the protection of the public and the Contractor's own employees, or otherwise applicable to the work. The Contractor shall obey such laws and regulations as may exist or be promulgated by the constituted authorities and shall use such foresight and shall take such steps and precautions as may be necessary to protect the public and his own employees from injury, loss, or damage to person or property and shall comply with all laws and governmental regulations and requirements in any way applicable to the work . . ."

"The Contractor, at all times throughout the performance of this Contract, shall take all precautions necessary to effectually prevent any accident in any place affected by his operations in consequence of the work being done under this Contract, and shall, to this end, put up and maintain suitable and sufficient barriers, signs, lights, or other necessary protection."

On some projects Ebasco has used even more specific safety clauses. These additions include the project's entire safety program in detail, and the degree of participation of each contractor. Projects using these contracts with detailed safety clauses have had very successful safety experience.

Safety is very important to client, employee, and public relations. A low accident rate brings about better employee morale and has a highly favorable effect in the community. Conversely, a high accident rate reflecting numerous injuries, deaths, or health hazards to employees and the public, can create a very unfavorable reaction to the company and to its product or service — particularly if it is a result of oversight, error, or skimpy design. The prestige of the consulting engineer also suffers if the client must request field changes to satisfy the requirements of his own safety department, or of governmental or insurance authorities. From the dollars and cents standpoint, safety is currently even more important because of the high cost of skilled labor, the high medical and claim costs, and the higher awards given by juries in public accident cases.



EXPLOSION HAZARD PROVISIONS — SAFE OUTSIDE STORAGE OF HYDROGEN CYLINDERS TO ELIMINATE HYDROGEN ACCUMULATION; ISOLATED BUSES FROM TURBINE. NOTE STAIRWAYS, KICKPLATES, RAILINGS.

Ebasco Safety Policy

We in Ebasco have the following safety policy with full management backing. It applies to our design and construction work and all our activities.

"Ebasco considers accident prevention an integral part of every job and is acutely concerned for the safety and health of the individual worker. But aside from all humanitarian aspects, it is recognized that unsafe performance is inefficient performance and that injury and damage expenses and the hidden costs of accidents seriously affect the economy of the construction operation. The highest safety standards must be maintained to the end that industry, the employees, and the public will recognize that 'An Ebasco Job Is A Safe Job.'"

Consulting engineers can help remove the consequences of human failure by eliminating the hazards before they are "hatched." Incorporating safety features in designs will accomplish this aim to the benefit of all concerned. ▲▲

FOREIGN INSTALLATIONS OF CENTRIFUGAL BOILER FEED PUMPS USING STEP-UP GEAR DRIVES

Customer	Location of plant	Number of pumps	Pump capacity gpm	Discharge pressure psig	Pump speed rpm	Types of drives	Motor size hp
Houilleres du Bassin du Nord et du Pas-de-Calais.	Harnes, France	6	918	1162	3600	4 motors and gears 2 turbines	800
Electricite de France	Gennevilliers, France	6	1310	1734	3820	6 motors and gears	1750
Kennedy Van Saun	Greece	2	300	1050	3600	1 motor and gear 1 turbine	350
Union des Centrales Electriques	Liege, Belgium	5	1180	1151	3550	3 motors and gears 2 turbines	1000
Kyndby Power Plant	Copenhagen, Denmark	4	1345	1564	3900	2 motors and gears 2 turbines	1700
Societa Edison	Genoa, Italy	6	855	1088	3800	4 motors with hydraulic couplings & gears 2 turbines	800
International G.E.	Sicily, Italy	6	715	1255	3700	4 motors and gears 2 turbines	700
Societa Meridionale de Elettricita	Naples, Italy	6	790	1216	3600	4 motors and gears 2 turbines	800
Cia Argentina de Electricidad	Argentina	2 5	1030 517	1235 1235	3700 3700	2 motors and gears 5 turbines	600
Societa Idroelettrica de Piemonte	Turin, Italy	3	814	1115	3800	1 motor and gear 2 turbines	700
Houilleres du Bassin du Nord et du Pas-de-Calais.	Dechy, France	6	730	1122	3750	4 motors and gears 2 turbines	700
Societa Termoelletrica Veneta	Venice, Italy	3	855	1095	3800	2 motors and gears 1 turbine	800
Mexican Light & Power	Lecheria, Mexico	6	833	1189	3900	4 motors and gears 2 turbines	800
Societa Romana Elettrica	Rome, Italy	2	1595	1105	3750	1 motor and gear 1 turbine	1250
Electricite de France, Arreghi Station	Paris, France	4	1211	1720	4050	4 motors with hydraulic couplings & gears	1650
Societa Edison	Piacenza, Italy	4	1160	1746	4030	4 motors with hydraulic couplings & gears	1750
Electricite de France, Arreghi Station	Paris, France	3	1211	1720	4050	3 motors with hydraulic couplings & gears	1650
Electricite de France	Gennevilliers, France	3	1300	1725	4100	3 motors and gears	1750
Electricite de France	Creil, France	8	1920	1670	4100	8 motors with hydraulic couplings & gears	2700
Electricite de France	Porcheville, France	12	945	2540	3880	12 wound rotor motors and gears	2000

Step-Up Gear Drives for Centrifugal Boiler Feed Pumps

IGOR J. KARASSIK
Manager,
Multistage Pump Section
Centrifugal Pump Division
Worthington Corporation

Ce exclusive

Igor J. Karassik is Manager of the Multistage Pump Section, Centrifugal Pump Division, Worthington Corporation. Born in Russia, he emigrated to Turkey in 1919, then to Paris in 1924. Coming to the United States in 1928, he received his B.S. and M.S. degrees from Carnegie Institute of Technology. He is a member of Tau Beta Pi, Pi Tau Sigma, and Sigma Xi.

He was employed by Worthington in 1934, as assistant to the Consulting Engineer on Centrifugal Pumps and was engaged in research and design work on single and multistage pumps. Since 1936, he has specialized in the application of multistage high pressure pumps, especially for power stations. His work also has included development and design of improved boiler feed cycles for central station power plants, a field in which he holds several patents.

Karassik has written numerous articles on centrifugal pumps for technical publications: as of May 1955, a total of 161 articles. Including reprints and translations, his articles have appeared in 48 different magazines and in 6 different languages.

THE SIZE OF TURBO-GENERATORS for steam powered generating stations is increasing, and operating pressures and temperatures are moving upward. The size of the centrifugal boiler feed pump drive is beginning to assume the proportions of the average generator of forty years ago. With these developments in mind, it becomes necessary to re-examine in some detail our reasoning in the selection of this pump drive.

Whether the steam turbine again finds favor in the eye of the power plant designer, or whether the gas turbine comes into widespread use, the electric motor driven boiler feed pump will remain the preferred solution for a number of installations and for a number of years. If the electric motor is to remain competitive with other drives, however, serious thought will have to be given to the use of a step-up gear between the motor and the feed pump.

The attention that the step-up gear drive rightfully deserves from the steam power plant designer is based on separate but complementary factors:

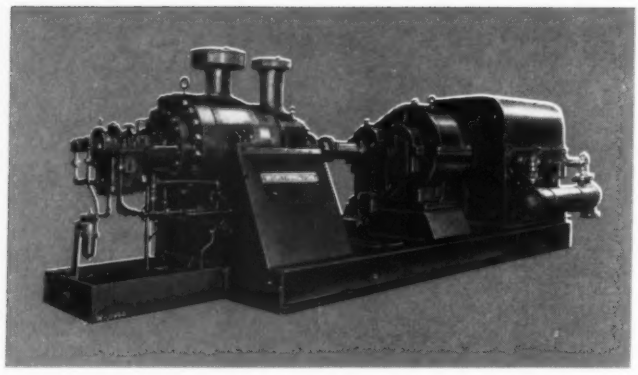
¶ In the range of sizes encountered in today's boiler feed pumps, the 2-pole, 3600-rpm motor is considerably more expensive than the 4-pole, 1800-rpm.

¶ The use of step-up gears divorces the pump from the limitation of 3600 rpm as an upper limit for direct motor driven units, making possible the use of speeds of 5000 to 12,000 rpm.

A certain amount of history needs to be recounted in order to explain the reluctance of some power plant designers to use step-up gears for boiler feed pump service. In the early days of low pressure steam power plants, boiler feed pumps operated first at 1200 rpm and then at 1800 rpm, and either squirrel cage or wound rotor motors were used. Pump designers brought out higher speed pumps when steam pressures started increasing, but for a long time these could only be used with steam turbines because even squirrel cage motors were not dependable at 3600 rpm.

By 1928, the 3600-rpm squirrel cage motor became a practical piece of equipment in the required sizes, and it was soon applied to boiler feed pump drives as a standard practice. In the meantime, operating pressures kept on growing, and by 1936, 1800-rpm pumps were obsolete. Wound rotor motors were not economically attractive at 3600 rpm, and the savings resulting from variable speed operation were not given much consideration in those days. Therefore, power plant designers chose to avoid the use of step-up gears (which would have been required with wound rotor motors) and specified direct connected squirrel cage motors.

Thus, the lack of interest with which power plant designers in the United States looked upon step-up gears stemmed from the fact that, until recently, 3600 rpm was considered a high enough speed for boiler feed pump service. A feeble attempt to obtain acceptance of step-up gears took place in the late 1930's, when the desire arose to use variable speed hydraulic couplings for boiler feed pump service. At that time, these couplings were not suited to operation at 3600 rpm, so some type of step-up gear was required if they were to be used at all. One very important installation was made in a New York State power plant, where the boiler feed pump unit consisted of an 1800-rpm squirrel cage motor, followed by a hydraulic coupling, then by a step-up



SEVEN OF THESE PUMPS AT ELECTRICITE DE FRANCE ARE DRIVEN AT 4050 RPM THROUGH STEP-UP GEARS.

gear, and finally by a boiler feed pump operating at 3600 rpm. Had the manufacturers of hydraulic couplings failed to follow with the development of a 3600-rpm design, there is no doubt that many additional units of a similar type would have been installed in the United States. This would have led to an earlier adoption of higher operating speeds, since the use of step-up gears would have eliminated a fixed top speed of 3600 rpm.

A greater interest in the application of step-up gears to boiler feed pump drives was always exhibited in those areas where the limitation of 50 cycle current precluded the use of speeds higher than 2950 rpm. Very important installations have been made, among them the Gennevilliers Station of the Electricite de France, where six boiler feed pumps were installed in 1947 to handle 590,000 lb per hr of 330 F water against a discharge pressure of 1734 psi. They operate at 3820 rpm and are driven by 1750-hp, 1450-rpm motors through step-up gears.

Another installation was made in 1947, involving six boiler feed pumps for the Centrale de Harnes des Houilleres du Bassin du Nord et du Pas-de-Calais. The motor driven pumps operate at 3600 rpm and are driven by 800-hp, 1450-rpm motors through step-up gears. Another important installation was made as far back as 1940, by the Electric Bond and Share Co., for the Shanghai Power & Light Co. Here the boiler feed pumps were driven at 4100 rpm through step-up gears. It is through the experience of such steam power plants abroad that American designers have the opportunity to recognize the reliability and advantages offered by the use of step-up gears on boiler feed pump service. To a great extent, it is as a result of the progressive attitude of the designers of these plants that an important step forward in the design and application of boiler feeding equipment can be taken.

Starting in 1950, there was a tremendous increase in steam power plant construction in Europe as well as in South America. The majority of the new plants built in Europe during the early stages of the expansion were financed from E.C.A. funds. These power plants were designed for either 850 psi, 900 F or 1250 psi, 950 F steam, and required boiler feed pumps designed for pressures of either 1100-1200 psi or 1600-1800 psi. The first range of conditions was met with axially split casing, volute type pumps, while the second required the application of solid forged steel barrel, radially split casing pumps.

These power plants are all generating 50-cycle current which permits a maximum synchronous motor speed of 3000 rpm. Yet, every order for boiler feed pumps placed in the United States was for pumps operating at speeds of 3500 rpm or higher. Further, all motor driven pumps on these orders were driven through step-up gears. (See Table).

The idea of installing gear driven units appeared strange to European power plant designers, and considerable resistance was first exhibited to its adoption. However, when the problems involved and the advantages of gear drives were thoroughly discussed with the ultimate customer, acceptance was obtained.

It may be interesting to consider some of the reasons that caused European power plant designers to select gear drives for these installations. At the time when American manufacturers built axially split casing boiler feed pumps operating at speeds of 1800 rpm, the prevailing boiler pressures never exceeded 625 psi. This style of pump was designed for a maximum discharge pressure of about 800 psi. In the early 1930's, when the 900-psi boiler came into wide acceptance, the trend to 3600-rpm operation, as opposed to 1800 rpm, was clearly defined. By 1935, the higher operating speed had become the standard for boiler feed pumps in the U.S.

Consequently, there was no incentive in 1950 to develop modern patterns for lower speed pumps, for the range and field of application at such lower speeds was narrowed to the point of extinction. Thus, the European designer, with 50-cycle drives to work with, had several choices. He could use gearing to bring pump speed up to 3600 rpm or above, or he could go to designs based on the obsolete, 1800-rpm patterns of 1928-30 vintage. As an

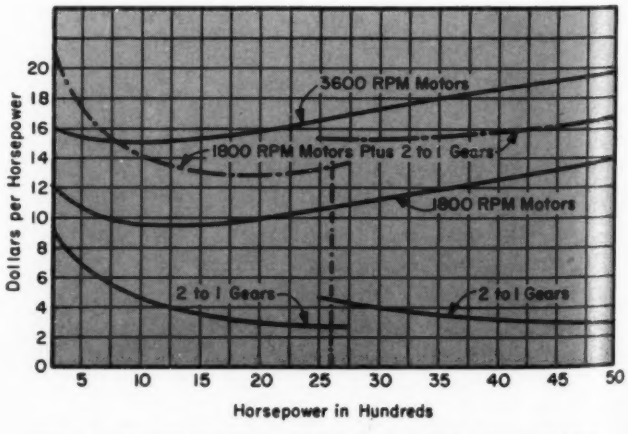


FIG. 1.—PRICE COMPARISON OF MOTORS AND GEARS.

alternate, a modern boiler feed pump of the solid forged steel barrel construction designed for pressures up to 1800 psi could be derated down to the speed of 2950 rpm. This would provide the capacities and pressures required for installations involving 850-psi steam turbo-generators. Such a solution, however, would have been extremely uneconomical. To begin with, operation on 50 cycles would have reduced capacities to 5/6 and pressures to 25/36 of those available on 60 cycle operation. In addition, the solid forged steel barrel pump is designed for considerably higher pressures than required here, and its use would have increased the pump prices anywhere from 75 to 100 percent. Such an increase in first cost could hardly be justified when modern 3600-rpm boiler feed pumps could be applied, driven by 1450-rpm, 50-cycle motors with step-up gears.

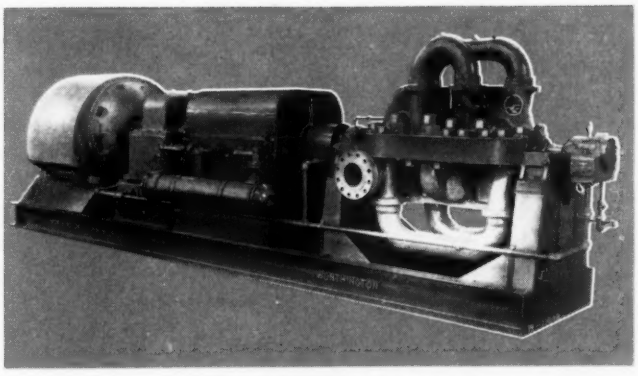
Finally, the recommendations for this type of drive were made by the manufacturer based on the knowledge that high-speed, precision type gears designed for long life and quiet, smooth operation were available for this service. There also was available a technical background involving successful applications of step-up gears for turbo-machinery.

Thus, the foreign installations shown in the table utilize step-up gears and modern boiler feed pump designs. Out of a total of 102 boiler feed pumps used at the stations listed, 76 are driven through step-up gears. The other 26 are steam turbine driven and, are mostly standby pumps. All reports available at this time indicate that the gears have been performing satisfactorily.

Domestic Possibilities

The success achieved overseas offers promise that domestic consultants might successfully specify step-up gears either to obtain higher operating speeds for motor driven pumps or to introduce very appreciable economies in the application of 3600-rpm pumping equipment.

Where could these economies be achieved? The 2-pole, 3600-rpm, squirrel cage motor is more expensive than the 4-pole, 1800-rpm motor in the range of drives required by modern boiler feed pumps. This increase in initial cost becomes more and more appreciable as the size of the motors are increased. This difference in price is graphically illustrated on Fig. 1, which shows the price of motors of 3600 and 1800 rpm as well as of 2 to 1 step-up gears. This is plotted in terms of price in dollars per horsepower against the size of the drive. It will be noted that from approximately 2600 hp, there is a break in the curve for gear prices. This is because the pitch line velocity reaches a value requiring special considerations, a special lubrication system, and special bearings. Therefore, the price rises to a new curve. When the price of gears is added to that of 1800-rpm motors, it becomes apparent that from



BOILER FEED PUMP DRIVEN BY A 1450 RPM MOTOR THROUGH STEP-UP GEAR AND HYDRAULIC COUPLING.

800 hp upwards, the motor and gear combination becomes less expensive than the equivalent 3600-rpm motor intended for direct drive.

As a matter of fact, at 4000 hp, the 6-pole, 1200-rpm motor becomes even less expensive than the 1800-rpm motor, and when the size of the boiler feed pump drive reaches this magnitude, it is better to use a 3 to 1 gear ratio for 3600-rpm pump drives.

These considerations remain no less true when a variable speed drive with an electric motor is contemplated. As long as the size of the drive is such that the price of a 3600-rpm hydraulic coupling is less than one designed for 1800 rpm, an 1800-rpm motor and a 2 to 1 gear can be used ahead of the hydraulic coupling. If the size is such that the 1800-rpm hydraulic coupling is cheaper, then the hydraulic coupling can be interposed between the 1800-rpm motor and the gear. It should be noted that hydraulic couplings are not available today for speeds in excess of 3800 to 4000 rpm. As a result, when higher boiler feed pump speeds are involved, the hydraulic coupling will have to be located between the motor and the gear.

Magnetic Drives

The variable speed magnetic drive, which has an efficiency comparable to that of the hydraulic coupling, has seen service in power plants, but never for boiler feed pump drive. In the sizes required it has never been developed for 3600 rpm. The introduction of a gear drive coupled to a 1800- or 1200-rpm motor will mean that the magnetic drive will probably become a definite competitor to the hydraulic coupling.

Finally, the wound rotor motor, abandoned as a boiler feed pump drive by 1930, may see service again as a variable speed drive. Its efficiency is comparable to the squirrel cage motor and hydraulic coupling combination, and its use would eliminate one piece of equipment, with its four bearings, from the motor-gear-hydraulic coupling combination.

The demand for high speed gearing for applica-

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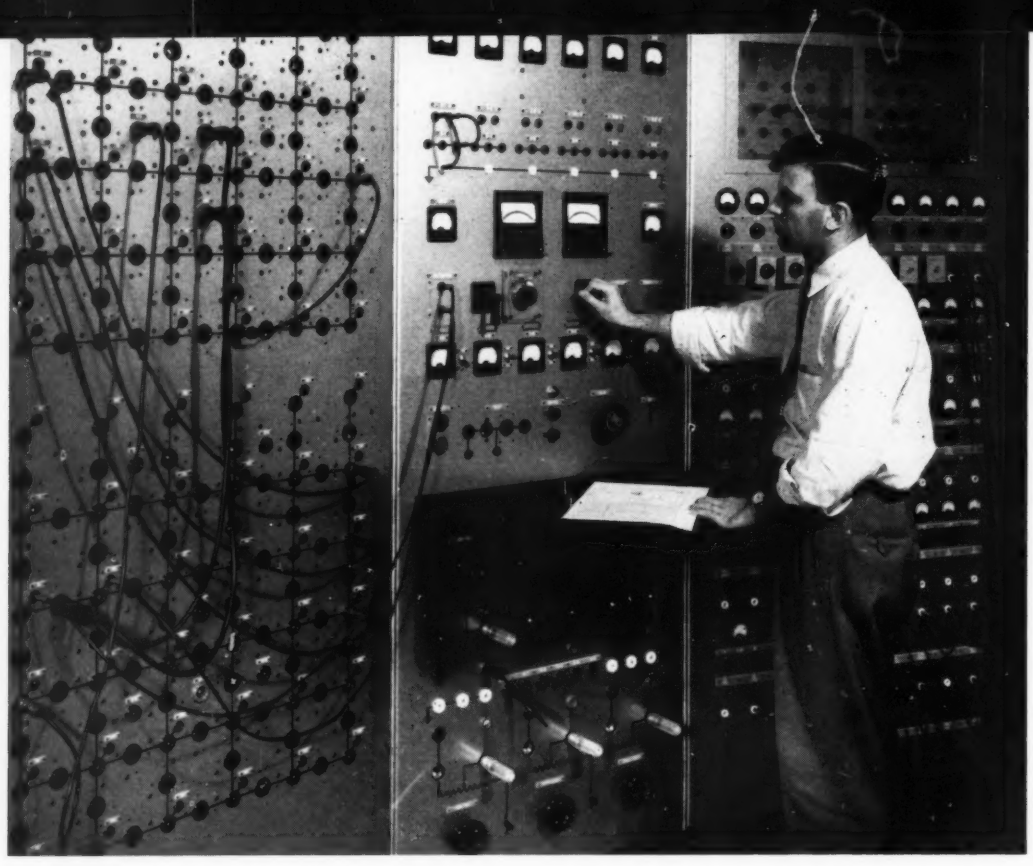


FIG. 1 — FRONT VIEW OF McILROY PIPELINE NETWORK ANALYZER AT MIDWEST RESEARCH.

Consultants Cut Time-Consuming Calculations on

Pipeline Network Computers

DR. SHELDON L. LEVY, Manager Applied Physics Division
LEON D. FINDLEY, Section Head Computing Service
Midwest Research Institute

DR. SHELDON L. LEVY

Dr. Sheldon L. Levy has directed work in both fundamental and applied research. After receiving his B.S. in Electrical Engineering and Master of Science in Mathematics at the Illinois Institute of Technology, he was granted his Ph.D at Brown University in 1952.

He has done extensive investigation of solid state physical phenomena by measurement of the attenuation of pulsed ultrason. He is an authority on wave propagation in anisotropic elastic media, ferromagnetism, and material stress analysis.

Dr. Levy was assistant professor of applied mathematics and had complete responsibility for the metals research laboratory of the Graduate Division at Brown University before joining Midwest in 1954.

LEON D. FINDLEY

Ce exclusive

Leon D. Findley attended Kansas State College, receiving a B.S. degree in 1943 and an M.S. degree in 1947. His professional experience includes development work on industrial electronic controls, and research and development on magnetic storage systems and electronic digital computers. An instructor at Kansas State College, Mr. Findley was a Signal Corps officer and a project engineer for Engineering Research Associates before joining Midwest Research Institute in 1950 as an Associate Physicist.

AS AMERICA's development continues, pipeline networks stretch farther in all directions, spreading in ever-increasing length and complexity from the hub of a metropolis to suburban areas, or from city to city. These pipelines, carrying gas, water, steam, sewage, or any of the various petroleum products, constitute the nation's greatest transportation system. In 1955, they will handle greater traffic than ever before, and construction of new pipeline systems or extensions to present networks will approach near-record proportions.

Consultants are well aware of the fact that a pipeline network constitutes an enormous investment, often ranking in the hundreds of millions of dollars category. With construction costs of such magnitude, it is imperative that the best possible results be obtained. Designs must eliminate the element of risk from material failure, inadequate pressure, inequalities of flow, or other harmful characteristics.

Until recently, engineers with the responsibility for pipelines projects had to rely entirely on tedious, complex, time-consuming calculations in establishing the system design. Most consultants would devise two or three alternate plans, check their feasibilities by long hours of hand calculation, and then decide on the best plan. Usually it worked out all right. Sometimes it did not, and financial loss was the unfortunate result.

McIlroy Pipeline Network Analyzer

In the last few years, however, the use of a unique analog computer, the McIlroy Pipeline Network Analyzer, devised by Malcolm S. McIlroy, professor of electrical engineering at Cornell, gradually has gained prominence as a replacement for tedious hand calculations. This instrument has been applied in designing new pipelines, checking and improving existing systems, completely studying the steady-state performance of pipeline networks with a minimum of computational effort and time, and solving many other problems.

Since the first of these analyzers was installed at Cornell in 1949, many consultants, oil companies, municipalities, and other firms and organizations have found wide application for the device. At present there are approximately a half dozen of its type in existence. Three of them, one at Midwest Research Institute in Kansas City, one at State College of Washington in Pullman, Washington, and one at Cornell University in Ithaca, New York, are available to consulting engineers. The cost is on a per diem basis and covers use of the machine and assistance of personnel trained in operation of the computer.

Operating from a direct-current power supply of 120 or 240 volts, or from a special motor-generator set, the analyzer can be adjusted to provide an automatic analogy for the analysis of any pipeline situation. It can perform in 30 minutes tasks of calculation that otherwise would require many hours or days. The answers are completely accurate, and no rechecking is necessary.

Typical Applications

At Midwest Research, successful results have been obtained for these typical problems.

¶ Determining the best location for pipelines.
¶ Selecting pipeline diameters for best combinations of economy and performance.
¶ Comparing alternate arrangements of systems planned for construction.
¶ Locating the source of operating difficulties or bottlenecks in existing networks.
¶ Studying the effects of choice of elevation of reservoirs or storage tanks.
¶ Evaluating pressure variations.
¶ Providing the information desired for preparation of constant-pressure contour maps.
¶ Checking the operation of transmission systems.
¶ Selecting the rating of pumps.
¶ Computing air conditioning system designs.
¶ Solving problems of low and high pressure gas distribution systems.

Analyzer Details

The McIlroy Pipeline Network Analyzer is a large device, approximately 9-ft high and 10-ft wide, built in vertical sections (additional sections may be

FIG. 2 — TECHNICIAN ADJUSTS McILROY PIPELINE ANALYZER AND INSERTS THE PROPER FLUISTORS.

McILROY ANALYZER IS BEYOND THE WINDOW AT REAR. GIRLS ARE OPERATING ELECTRONIC DIGITAL COMPUTERS.

added as conditions demand) as shown in Fig. 1. The panel on the left can simulate more than 100 pipelines, while the panel on the right can simulate more than 40 loads. From 6 to 10 sources also can be "read" into the device.

Key to the success of the analyzer is the use of specially developed tungsten-filament, nonlinear resistors — called fluistors. As engineers long have known, electricity can be used to provide a qualitative analogy for the solution of fluid-flow problems. But a collection of ordinary resistors arranged to represent a pipeline will not do the job, because ordinary resistors perform according to a law of direct proportionality that cannot be applied to pipelines as used in practice. Therefore, to provide an automatic analogy, the special nonlinear resistors, or fluistors, were developed.

Fluistor Characteristics

These fluistors are manufactured in a series of about 200 ratings, or coefficients, to represent a wide range of pipeline characteristics: diameters, lengths, and roughnesses. The voltage across each fluistor varies as the 1.85 power of the current through it, thus providing an excellent analogy (Hazen-Williams formula) to the variation of the friction head loss with flow rate in a pipeline or duct. In practice, these fluistors are inserted in the rear of the left-hand panel of the analyzer (Fig. 2).

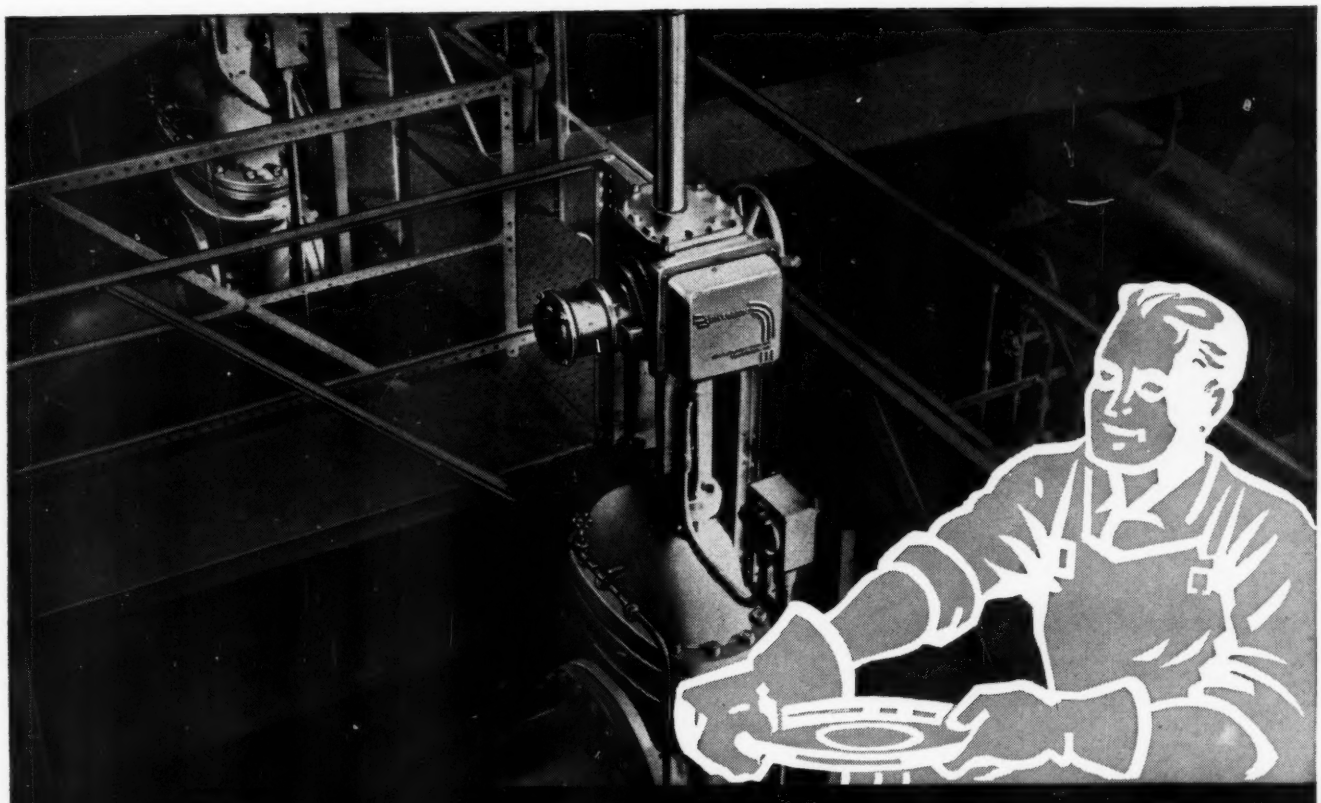
When an operator is studying a simple problem, in which only flow and pressure drop values are important, only brightness of the fluistor filaments needs to be observed. For this condition the brightest filaments would correspond to the pipelines that operate with the largest friction losses. However, other readings, taken from controls, also are used in more complex studies.

Typical Results

A recent test on the analyzer indicates the operating speed of this unique instrument. In one day, including the time to set up the problem, the flows and pressure drops in 70 trunk mains of a municipal water distribution system, supplied from 5 sources, were readily determined. The following day 6 alternate conditions, with various reservoir elevations and sets of loads, were studied. This work subsequently led to the approval of a large construction project based on the computer data.

Another problem conducted on the analyzer was that of seeking to prevent sudden faults in a fluid distribution system. A complete pipeline network was set up with fluistors taking the role of the pipelines, current representing flow, and voltage designating head loss. The analyzer promptly indicated bottlenecks in the network and enabled the owners of the system to make prompt repairs.

Computer studies also are of great value in simulating special conditions in a pipeline. For example, a municipal water supply may be subjected to increased pressure in a time of flood or to greatly increased flow during heat waves. Such unusual load conditions can be simulated in advance on the analyzer to reveal weak points in the system that could readily fail. Then changes in the design of new networks or repairs to strengthen existing systems can be made, thus avoiding expense, inconvenience, and hardship at a future time. ▲▲



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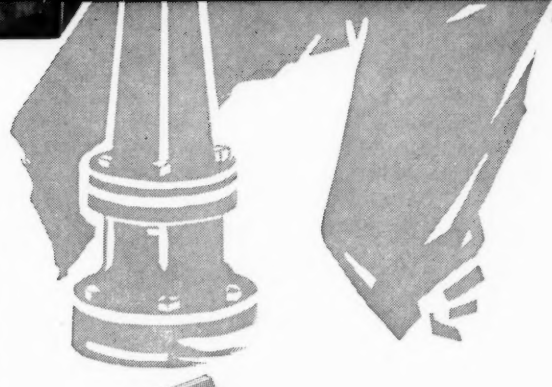

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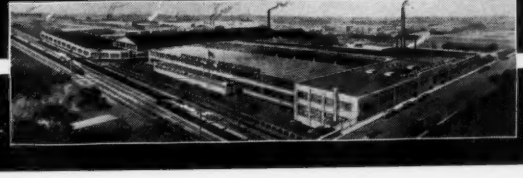

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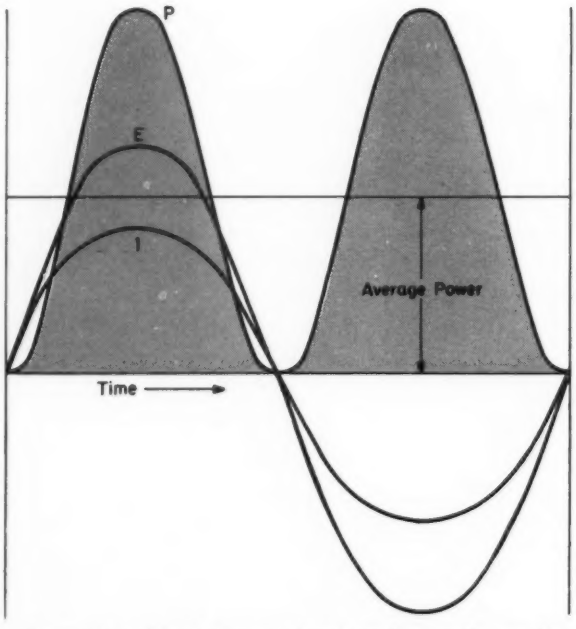
When Figuring Electric Energy Costs

Take a Look at Power Factor

HAROLD E. McCONNELL, Consulting Engineer

Power Factor Review

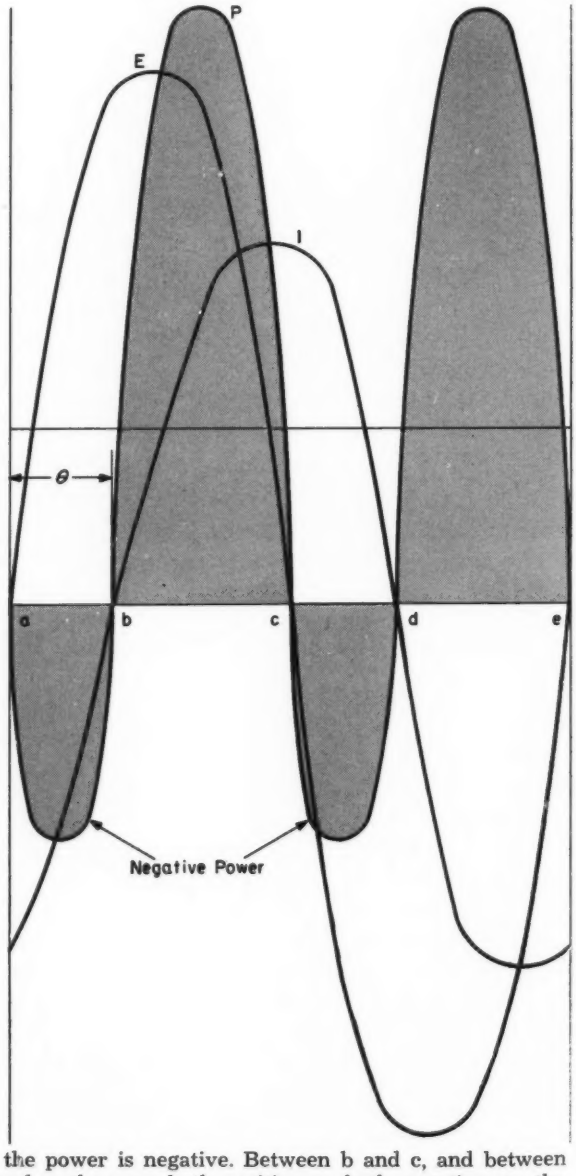


Power in a direct current circuit under steady conditions is the product of the volts across the circuit and the current flowing through the circuit. This same definition applies to alternating current circuits, provided instantaneous values of volts and amperes are considered.

When the frequency waves for both voltage and current are in phase, as shown at the left, then the power factor is unity. During the first half of the cycle, voltage and current are both positive values and therefore their product is positive. During the second half of the cycle, voltage and current are both negative, again providing a positive product. Hence, the products obtained by multiplying instantaneous values of E and I give a sine wave P of the power in the circuit through a cycle, and this power is always positive.

If voltage and current differ in phase by an angle θ, which is less than 90 degrees but greater than zero degrees, the resultant power curve P assumes the form shown at right. Values of P are obtained from the formula: $P = EI \cos \theta$. Cos θ is called the power factor of the circuit.

At points a, b, c, d, and e, either the voltage or the current is zero and, as a result, the power is zero. Between a and b, and between c and d, the current and voltage are in opposition (one is positive while the other is negative),



so the power is negative. Between b and c, and between d and e, they are both positive or both negative, so the power is positive. Average power is positive and is shown here to the same magnitude as average power in the left-hand drawing. Note how much more voltage and current are required to produce the same average power when the power factor is less than unity, as at right.

In the formula $P = EI \cos \theta$, P is the "real" power (measured in kw) while EI is the "apparent" power (measured in kva). It is clear that the lower the power factor, the lower the ratio of real power (P) to apparent power (EI)—and the higher the useless (reactive) power.

Harold E. McConnell has a B.S. in E.E. and he is a Registered Professional Engineer in Texas. During the first 8 years of his professional career he was successively Assistant Geodetic Engineer with the U.S. Coast & Geodetic Survey and Geophysical Engineer and Party Chief for Shell Oil Co. and Brown Geophysical Co. In 1940, he switched to design engineering, serving as Electrical Design Engineer with Austin Co. and Senior Electrical Design Engineer with Dow Chemical Co. (Houston Engineering Office) and H. K. Ferguson Co. until entering private practice in 1949 as a consulting engineer specializing in major industrial distribution systems. During World War II he spent 4 years in the U.S. Army as Signal Corps Officer assigned to the Air Force, being discharged as a Major, the rank he now holds in the active Air Force Reserve. He has written a number of technical articles, and he is currently electrical editor on the staff of The Slide Rule, **a publication of the Houston Engineers Club.**

ELECTRIC POWER usually represents a very small, but direct, part of the manufacturing costs of a finished product. Just like the other raw materials used, it is bought in specific quantities under contract prices, FOB the factory, i.e. the generating station. The "freight" or delivery cost from the generating station to the plant service entrance depends upon the shipping method specified by the purchaser of the electric power.

Delivery Costs vs Power Factor

Delivery costs are directly related to the power factor of the plant, although electrical characteristics within the plant determine whether the power factor is high or low, and these characteristics are beyond the control of the utility. It costs the utility company more to deliver a given amount of power to a plant with low power factor than to a plant with high power factor. For this reason certain utilities apply a price reduction for high power factor, some exact penalty charges for low power factor, while others make no distinction.

Nearly all utilities using penalty rates assess only the bare additional cost or even less. They make no profit on the delivery. Thus, most utility companies are vitally interested in co-operating with consultants who are engaged in power factor improvement surveys. Often the utility has more to gain by improved power factor than the purchaser.

In some plants, however, the savings in choosing the cheapest delivery method may not be enough to spur management to action. If the plant must invest money in advance, this is in effect an escrow payment to guarantee lower delivery charges over a future period. Some of the smaller plants with limited capital may reason that this amount of money could be used to better advantage elsewhere. The relatively small monthly penalty charge is not seriously felt, and it only applies as the power is actually drawn to meet the load requirements.

But it is a dangerous fallacy to assume that the need for power factor improvement can be judged solely by decreased delivery costs. There may be additional problems inside the plant that should be studied by a competent electrical engineer. For example, excessively low power factor can affect the operation, efficiency, and life of much of the electrical equipment. Under such conditions power factor improvement can be self-amortizing over a surprisingly short period and is of distinct advantage to both purchaser and seller.

What Power Factor Is

Power factor often is defined as the ratio between "real" power and "apparent" power in an alternating current system. (The term does not arise for direct current systems because the apparent power is the same as the real power, the ratio is unity, and therefore the power factor is always unity.) "Real" power is the actual power consumed in heat and mechanical work. "Apparent" power is the power supplied by the generator to meet the demands of the circuit. Because of the peculiarities of electrical equipment elements when subjected to ac voltages, some of the initial supply of apparent power gets trapped in the circuit and cannot be released from the circuit to perform useful mechanical work. It simply circulates back and forth between the generator and the load device, adding to the heat losses as kilowatt hours of useless power expended in overheating all the system elements.

Since the amount of heating caused by the power flowing through an electrical unit governs its design, equipment power ratings are based upon apparent power (kva rating) rather than the useful power (kw rating). If the ratio of real power to apparent power is low (low power factor) the size of each component must be increased enough to dissipate the large, unwanted amount of circulating power and thereby avoid serious thermal overloads. Conversely, if the power factor of a circuit is nearly unity, there is not enough useless power circulating in the system to worry about. Usually it is practical to accept a small quantity of useless power because the cost of correction to absolute unity power factor is out of proportion to the economic benefits.

Reactance

A good way to understand why this useless power exists comes from the realization that in ac transmission, energy continuously transfers back and forth from the electric field in the conductor to the magnetic field surrounding the conductor. If the circuit element contains "reactance" all of the energy

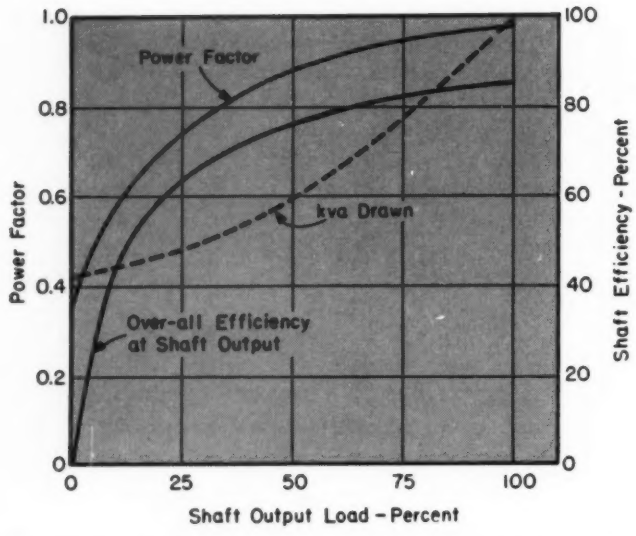


FIG. 1—TYPICAL CURVE FROM FIELD TEST DATA ON A 7½ HP, 3 PHASE SQUIRREL CAGE INDUCTION MOTOR.

does not get into the magnetic field at exactly the right time to be converted to useful work. "Reactance" is simply a term that expresses this fact in electrical units for calculations. It is caused by the physical arrangement of conductors to each other, and to magnetic cores and windings.

Reactance, and the power factor it causes, can be either leading or lagging. Leading power factor (caused by leading reactance) means that some energy arrives at the using point too early to be fully used. Lagging power factor means that some energy gets there too late. Unity power factor means that all of it gets there right on time for useful conversion. Part of the problem of the electrical engineer in applying power factor correction is to avoid overcorrection, since with leading power factor he again gets the same ratio of useless energy—plus some other undesirable effects. For the majority of plants, an 88 to 95 percent lagging power factor is most economical.

Characteristics of Circuit Elements

All induction equipment has an inherent tendency to create lagging power factor, unless the lag is compensated by special methods. In induction motors the energy must be transferred to the magnetic field right on time in order to be effective, since it is now generally believed that the useful work reaction takes place in the magnetic field. It makes little difference to anyone but the electrical engineer whether the power factor ratio leads or lags since either way it specifies an amount of useless power circulating in the system.

Synchronous Motors

The so-called synchronous motors can operate at unity power factor. They are ordinarily quite expensive, their over-all efficiency is usually not significantly different from that of the squirrel cage induction motor, and they require extra auxiliary equipment and controls. However, they will perform certain jobs, such as constant synchronous speed applications, that the ordinary induction motor cannot do. Synchronous motors can be designed to supply not only the reactive compensation needed in their own primary windings but additional compensation to make up for deficiencies in neighboring motors. They are a useful (although not always the cheapest and best) way to apply power factor correction and are quite widely used for this purpose.

Transformers

Transformers are induction machines which have a relatively small lagging reactive effect compared to their full load rating. This lagging reactive component is very nearly constant, regardless of the transformer loading, and adds vectorially to that load. When operated at or near full load the transformer is a high power factor device because its reactive component is a very small percentage of its full load rating, but the power factor tends to decrease somewhat with lighter loading. Transformers are not serious offenders in power factor problems.

Special Purpose Units

Electric arc furnaces, welding machines, and many other special purpose units are serious offenders and may demand unusual power factor correction methods. Their operating characteristics pose many problems, such as very sudden and erratic demand factors, which usually require special treatment.

Squirrel Cage Induction Motors

The squirrel cage induction motor, well known for dependable performance under severe operating conditions, is another induction device that contributes lagging components. Significantly, however, the three phase squirrel cage motor is not a low power factor device except in some of the very small sizes. It provides power factors from 80 to 90 percent, and its efficiency approaches and sometimes exceeds those of the synchronous motor if operated at or near its full rated load. But, like the transformer, its reactive nature demands a nearly fixed amount of lagging component, and if it is performing light work loads, that work is done at rather low power factor. It also loses efficiency and power factor drops sharply as the work load decreases. Fig. 1 shows a typical performance curve for a three phase squirrel cage induction motor.

Cables

All parts of an electric circuit or machine are at least slightly reactive in nature, but when the reactive effect is so small as to be negligible the element is called "resistive." Incandescent lights are an example of resistive elements because their power factor is nearly unity. Cables have some reactive component, usually lagging, but sometimes leading. The reactive

components of cables are not ordinarily large enough to make a really serious contribution to low plant power factor. They are, however, frequently just large enough to create annoying and sometimes difficult problems of voltage regulation in a plant.

Causes of Low Power Factor

In the average plant, electric motors are the major power consuming load. Even though the three phase induction motor has a reasonably high power factor at normal loads, certain necessary factors in plant operations may combine to lower the average power factor on these motor loads.

Frequent starting and stopping. Many plant operations depend upon frequent starting and stopping of a large number of motors in sequence. Since the starting inrush current is almost purely reactive and is several times the normal running current, this has a relatively large effect in lowering the plant's power factor during the brief starting period. Of course, occasional starting and stopping of a few individual motors has little effect on the daily average power factor of the plant as a whole.

Step cycle loads. Certain motor driven machinery automatically loads and unloads in step cycles. For example, on a compressor with steps of 100, 50, and 0 percent, the motor is allowed to run idle rather than shutting off at the 0-percent step if the loading is sufficient for frequent operation. Motors running idle show a very low power factor with about 40 percent of full load kva. Thus, when these compressors are large (as they usually are) they contribute heavily to low power factor conditions. This does not mean such motors should be shut off rather than run idle; other factors may make this the most economical operating method.

Motor size vs load. Some plants have remarkably constant motor loads with nearly all motors running continuously. But the practical adjustments to actual work loads as compared to the original theoretical design calculations may result in many motors performing only 50 to 75 percent of their rated nameplate capacity. The curves in Figs. 2 and 3, averaged from one manufacturer's published data, show how the power factor of induction motors decreases as the load decreases. (These curves do not take into account the plus and minus quantities that may be obtained for a particular size and type of motor or the special purpose modifications that may be made on practically all ac motors.)

Concentrations of small motors. Reference to the curves immediately indicates that plants with a preponderance of the smaller motors naturally will have a lower average power factor than those with the larger sizes. However, this is not to say that such plants should use larger motors unless the load groupings can be made correspondingly larger. The smallest motor that is otherwise suitable for the job is ordinarily the most efficient and economical.

Large single phase loads. Single phase motors are very useful and convenient, but they have notoriously poor power factors. But even if the single phase loads are largely high power factor lighting loads, temporary urgency may require that these single phase loads be applied to a three phase system in a very unbalanced loading arrangement. If the system is extremely well designed, such unbalanced loading may not be serious. But if the system, or some major transmission line, is inadequate to cope with such situations, large and undesirable effects, including an appreciable reduction of plant power factor, may occur and impair the operating efficiency.

Special purpose equipment. Heavy concentrations of inherently low power factor equipment, such as the arc furnaces, welders, and other special purpose units, are found in some plants. Modern design tendency is to recognize this as a power factor problem right from the start, and many such plants have corrective features built in initially. Where problems arise, they are as likely to be from over-correction as from under-

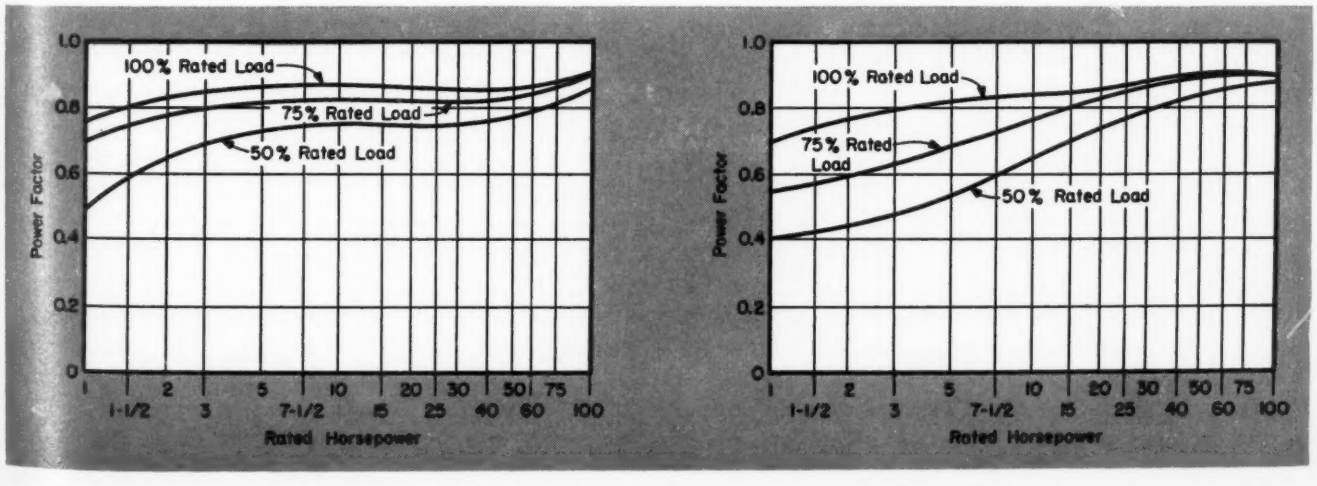


FIG. 2 & 3—POWER FACTOR VS LOAD FOR 3 PHASE SQUIRREL CAGE (LEFT) AND 3 PHASE WOUND ROTOR MOTORS.

correction. Plants using a limited amount of such equipment only sporadically have little to worry about if the power factor is found to be too low only when such equipment operates, because it is a relatively small part of the total plant load.

When to Improve Power Factor

Power factor improvement is decidedly economical for industrials with in-plant generation that need additional capacity. A 5000-kva generator and prime mover combination will safely deliver 4000 kw of real power at 80-percent power factor, because the apparent power flow is then 5000 kva. If the plant power factor is improved to 90 percent, the real power becomes 4500 kw — a net gain of 500 kilowatts of useful power without buying any new generating equipment. Of course, the turbine or prime mover must be capable of continuous performance at the 4500-kw loading. Most turbines nearly conform in work ability to the kva rating of the generator, but some do not.

If the power factor had not been improved, new generating capacity would have been required to supply the additional 500-kw load. Its cost may have been from $300 to $600 per kw. Depending on the problem in the particular plant, the cost of power factor improvement could have been as low as $20 per kw released and certainly not above $100 per kw released. Besides this saving, a slight increase in generating efficiency could be expected, thus reducing fuel costs.

Power Factor in Utility Plants

Public utilities are faced with this exact problem when their customers insist on low power factor delivery conditions. Assume they must invest in 1,000,000 kva of generating capacity and like amount of transmission equipment. If the average power factor on these machines is 70 percent, they must derive their revenue from only 700,000 kilowatts of useful power sold to the customers. Many areas have had conditions of power shortages that could have been partially relieved to the benefit of all concerned by power factor improvement of as little as 10 percent.

Since the entire system inside the plant expends kilowatt hours in heat losses, excessive apparent power may warrant power factor correction. In a big and well designed system, such conditions are unusual, and extra losses are generally negligible. For a small or inadequate system the extra heat loss may be a very significant, although not major, part of the total loss due to low power factor. Simple calculations by an engineer familiar with the components of the system will easily determine whether the extra heat losses are significant, and this will permit economic evaluation of the required correction.

Unfortunately, the choice of whether to make power factor improvement is not always based upon simple arithmetic. If additional heat losses from heavy, low power factor loads endanger cables, transformers, and other electrical equipment in the plant, the choice does not depend primarily upon the small savings to be realized from power billings. Both the value of the accelerated depreciation rate of major items of the installation, and to some further extent, the increased maintenance costs on overloaded equipment must be considered.

Factors to Consider

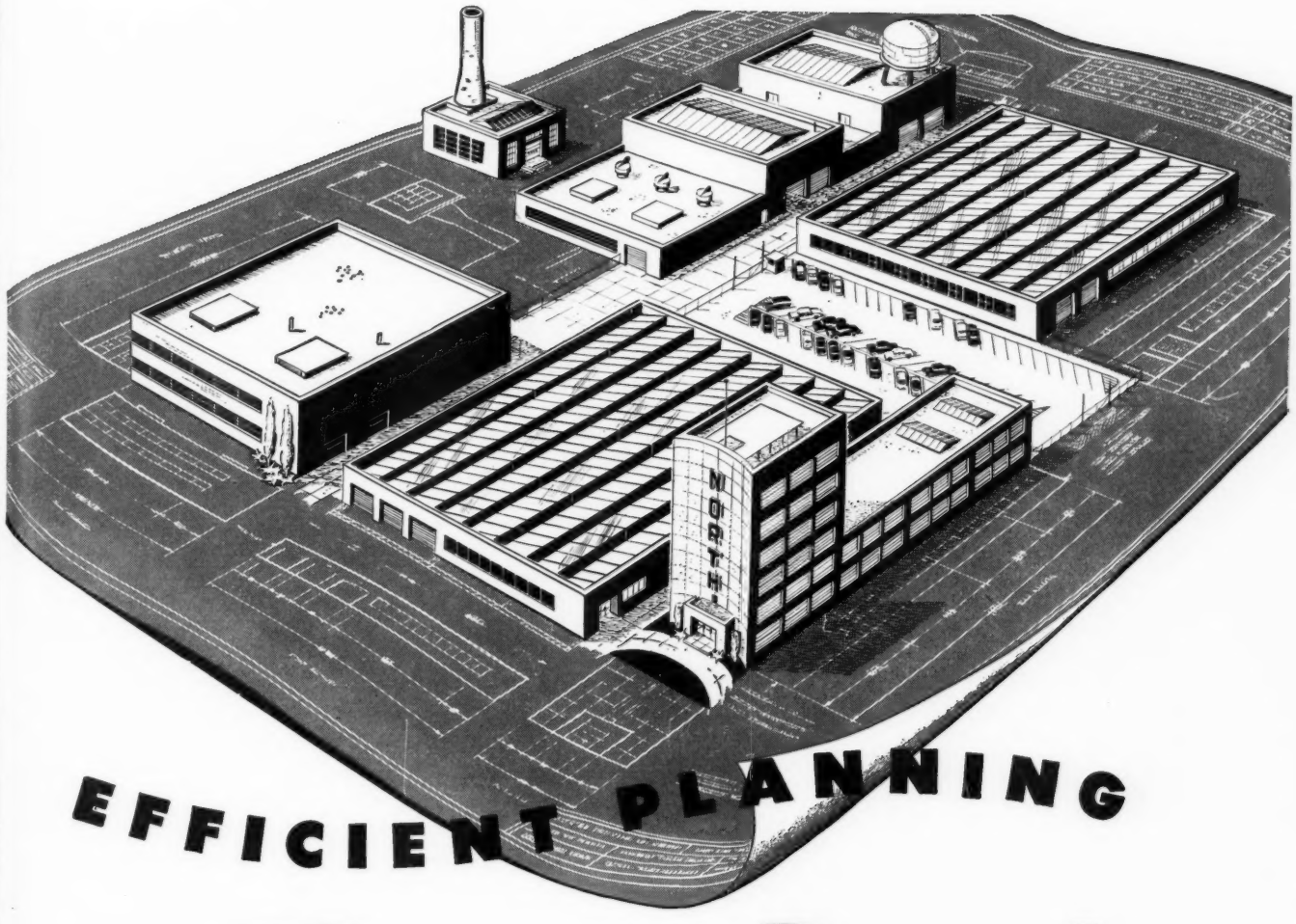
The type of electrical system, its construction, its age, and its state of repair are all factors to consider in connection with power factor improvement programs. If individual motor branch circuits conform to or are better than the minimum standards of the National Electrical Code, there is usually little danger of overloading a particular branch circuit simply because its motor operates at lower than normal power factor.

Heat losses in the motor are proportional to apparent power, and if a motor operates at a low power factor because of light loading, the motor efficiency drops off somewhat. But since the apparent power at light loading is always less than the full load apparent power, under otherwise correct conditions, the motor is able to harmlessly dissipate the heat. The net effect is simply that kilowatts are purchased at the higher cost for low power factor, and these purchased kilowatts provide proportionately less useful horsepower output at the motor shaft. The exception to this is that with a relatively small unbalanced voltage on a three phase system the apparent power flow through the motor windings becomes greatly unbalanced. Then the motor is in danger of serious thermal overload, regardless of the load it delivers to the shaft.

Main feeders, however, frequently are sized for expected demand factor or load factor at some anticipated power factor. If the original design underestimated the demand and overestimated the average power factor, or if load increases have been subsequently added, that main feeder may be in trouble. Relatively small increases to real power on a few large motors, coupled with low power factor contributions from other sources, may overload the kva capacity of the feeder.

Hidden Losses

It seems necessary to overemphasize the importance of power factor improvement for the sake of those plants with minimum systems and a variety of the so-called hidden losses. The engineer has a difficult problem to focus attention on these hidden losses, but he does no real service to his client if he alarms them over pennies involved in power factor cost, but fails to inform them of dollars wasted in hidden losses. In discussing these problems the consultant should make the client understand that while power factor improvement is not always necessary, correctly applied it cannot do any harm. Under certain conditions it can bring benefits far beyond the obvious dollar savings from reduced power bills. ▲▲



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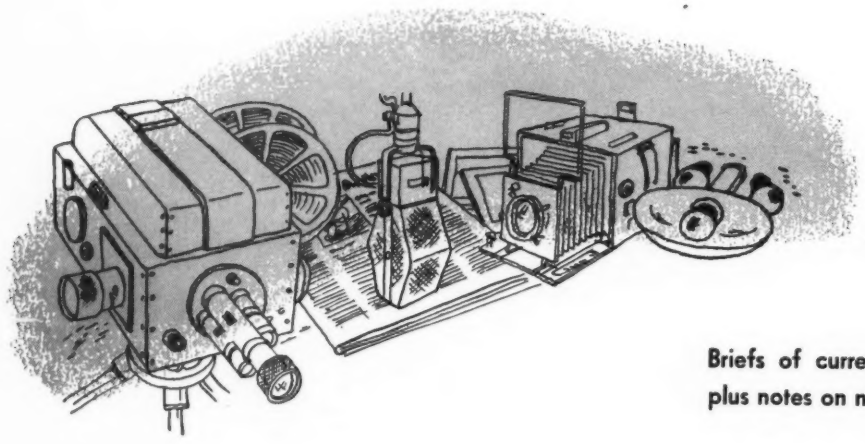


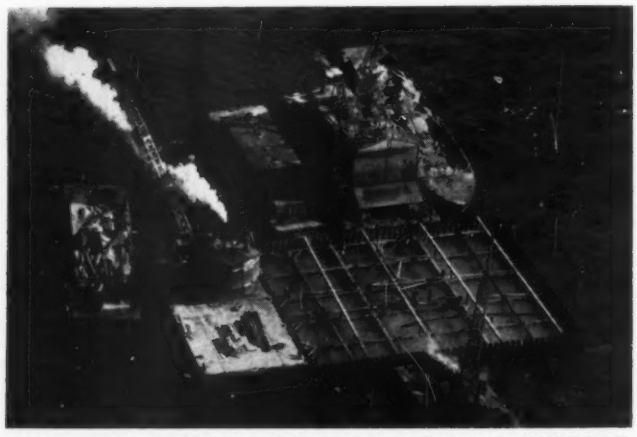
NEWS

Briefs of current interest to the consulting profession plus notes on new equipment in the field of engineering

Wind Tunnel Tests on Scale Model Prove Safety of Mackinac Bridge

Now, approximately two years after determination of design and award of contracts for the Mackinac Bridge, wind tunnel tests have been completed on a large-scale dynamic model of the bridge. No modification of the design has been found necessary. The report shows that "Tests at angles of attack up to 20 degrees and over the full range of velocities available have failed to develop any indication of instability."

The five mile long bridge, which will join the upper and lower peninsulas of the state of Michigan when



CONCRETING OPERATIONS ON NORTH CABLE ANCHORAGE.

completed in 1957, presented unusual engineering problems. The Straits of Mackinac are subject to severe storms with winds of high velocity and are completely frozen over during several of the winter months. Also, in the middle of the five miles, in the deepest water, is a wide glacial gorge.

The designer of the bridge, Dr. D. B. Steinman, with his associate consultant, Glen B. Woodruff, utilized the relatively new science of suspension bridge aerodynamics to eliminate the cause of aerodynamic instability: the vertical and torsional forces tending to produce oscillations.

To span the submerged canyon, the world's largest suspension bridge is being built—8614 ft from anchorage to anchorage. The central span, from tower to tower, is 3800 ft—300 ft longer than the span of the George Washington Bridge and exceeded only by the 4200 ft span of the Golden Gate Bridge. The foundations under the two main towers, one at each rim of the gorge, reach 200 and 206 ft below water surface. Suspension bridge cables are carried on steel towers 550 ft high; and the suspended trusses, carrying the roadway, have a normal height of 155 ft above the water.

Because of the unusual brecciated rock formation, geologists and soil-mechanics authorities made exhaustive geological studies, laboratory compression tests, and "in-place" load tests on the rock under water at the site. These tests established that the rock under the Straits can safely support more than 60 tons per sq ft—four or more times as great as the greatest possible load that will be imposed on the rock by the structure, including the combination of dead load, live load, wind load, and ice pressure. Foundations were proportioned to keep the maximum possible resultant pressure below 15 tons per sq ft on the underlying rock.

According to the most recent engineering literature on the subject, maximum ice pressure obtained in the field is 21,000 lb per lineal ft of pier width, and the greatest ice pressure producible in the laboratory is 23,000 lb per lineal ft. With this maximum possible ice pressure multiplied by five, and the safe foundation pressure divided by four as a basis for design, the combined factor of safety is twenty for the design of the piers under any possible ice pressure. Concrete of the piers is further protected by steel sheet piling, steel caissons, and armor plate.

The greatest wind velocity ever recorded at the Straits, 78 mph—which represents a wind force of 20 lb per sq ft—was multiplied by 2½ for the design. The stiffening trusses are 38 feet deep, or 1/100th of the span length. This is the same ratio adopted for the proposed Severn River Bridge in England, and 68 percent greater than the ratio of the Golden Gate Bridge. According to Dr. Steinman, the Mackinac Bridge will be the most stable suspension bridge, aerodynamically, that has ever been designed.

Contributing to this aerodynamic stability is the provision of wide open spaces between the stiffening trusses and the outer edges of the roadway. Trusses are spaced 68 ft apart and the roadway is only 48 ft wide, leaving open spaces 10 ft wide on each side for the full length of the suspension bridge. Effectiveness of this feature was demonstrated to the profes-

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Bridge Passes Safety Test

—*Starts on page 68*

sion by Dr. Steinman in 1940, and this feature has since been used in the construction or reconstruction of all large suspension bridges. Also, the equivalent of a wide longitudinal opening is provided in the middle of the roadway. The two outer lanes, each 12 ft wide, are made solid. The two inner lanes and the center mall (24 ft of width) are made of open-grid construction.

Maximum torsional stability has been secured by providing two systems of lateral bracing in the planes of the top and bottom chords. (This feature has recently been added to the Golden Gate Bridge at a cost of $3.5 million.)

In addition to the suspension bridge, twenty continuous-truss spans over the deep portions of the water-way range in length from 560 to 330 ft. Use of the Prepakt method for placing concrete in the foundations has enabled a new world's record to be established for underwater concrete placement from a single floating plant: 5050 cu yd in a 24-hr day.

The superstructure contract (structural steel and cables) for $44,532,900 is the largest single contract the United States Steel Corp. has ever received. Merritt-Chapman & Scott Corp. are substructure contractors and Prepakt Concrete Co., Div. of Intrusion-Prepakt, Inc., the subcontractor.

Air for Supersonic Wind Tunnel Dryed in "Building That Breathes"

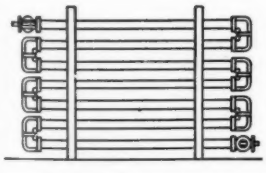
The $32,850,000 supersonic wind tunnel under construction at the Cleveland laboratories of the National Advisory Committee for Aeronautics posed unusual engineering problems. The tunnel will be capable of speeds up to 3½ times the speed of sound —about 2660 mph at sea level. It will provide U.S. aeronautical scientists with facilities for testing full-scale jet engines, guided missile power plants, and aircraft components under supersonic conditions never before attained.

Moist or contaminated air would seriously effect accuracy of the delicate instruments used in the

AIR ENTERS BUILDING AT FAR RIGHT AND AFTER BEING DRIED AND PURIFIED LEAVES THROUGH FUNNEL AT LEFT.

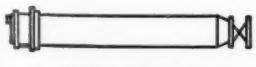
Another reason why,
EBKO *is best for complete piping service . . .*

EBKO piping systems can save you thousands of dollars



Stack Heat Exchangers

Line Type Heat Exchangers



Suction Heaters

Cast Iron Steel

EBKO
Complete Prefabricated Piping Systems

• EBKO custom designed piping systems are the absolute highest of quality, made with the finest of materials, sold at competitive prices. The keynote of EBKO design is simplicity. Here are some reasons why EBKO should be your first and last choice:

INSTALLATION EASE. EBKO pipe is built stronger than any other prefabricated pipe. Long lengths can be assembled on the ground and raised or at the side of the trench, then lowered. No special handling methods or tools and no special structural supports are needed.

DURABILITY. Never has an EBKO prefabricated piping system failed. EBKO piping joints, both *interior* and *exterior,* can be tested and visually checked after each is assembled. Before you backfill the trench you know the job is sound.

ENGINEERING SERVICE. EBKO engineers will give job-site service prior to and during installation. These are highly trained, experienced men in all phases of piping.

DELIVERY. The simplicity of EBKO design means complete systems can be assembled and shipped in the very minimum of time.

NATIONWIDE SERVICE AND SALES. Factory representatives in every major city are located throughout the United States to answer any question that may arise.

. . . there are many, many more reasons why EBKO should be your first and last choice. Call your local EBKO Representative and let him show you how to cut your piping system costs. Write for details—no obligation.

E. B. KAISER CO.

Since 1890

2110 West Lake Avenue • Glenview, Illinois
Phone: Glenview 4-4500

FOR STEAM • HIGH TEMPERATURE WATER • CHILLED WATER • VISCOUS LIQUIDS

Air for Supersonic Tunnel

—Starts on page 72

tests. To house air drying and purifying equipment, NACA engineers have designed and constructed a six-story "building that breathes."

The building will be sealed vacuum tight and subjected to a maximum interior temperature of 350 F for a period of four hours. To allow for expansion and contraction under the varying interior temperatures, curtain wall "skin" of the building is made up of 14 gage, metallic coated, carbon steel panels manufactured by H. H. Robertson Co., of Pittsburgh. Side laps of these Q-Panels permit the necessary expansion and contraction. Further, the building is split down two sides and joined with a butyl rubber seam 8 in. wide which "bulges" as the building expands. Base of the structure is also set in a butyl seal to compensate for expansion against the base.

Of the 25 steel support columns, only the center column is stationary — embedded in concrete. The others rest on perforated steel plates in which graphite bronze is imbedded. The columns move back and forth on the bases, the graphite bronze serving as a lubricant.

Atmospheric air is drawn into the building by two compressors through five banks of 19 louvres each, located on the west side of the building, and passes through frames of cellulose fiber filters to remove dust and other impurities prior to the air drying.

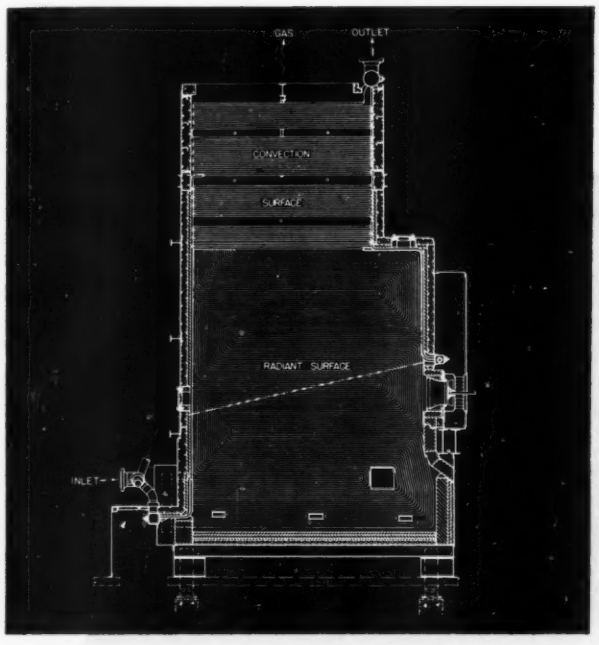
Drying area consists of six horizontal beds of activated alumina which remove moisture from the air to a dew point of –40 F before it enters the transition section—a funnel attached to the east side of the building. Temperature of the building is only slightly higher than exterior temperature when the tunnel is in operation. It is during the drying of the alumina after it has become saturated that the building is subjected to the 350 F.

"Window of Tomorrow" Designed For Socony-Vacuum Building

It has been estimated that within ten years all new buildings will have built-in air conditioning. Efficiency of air conditioning depends largely on how successfully window openings are sealed. Besides being effectively sealed, windows, ideally, should be dust and storm proof, easy to clean from the inside, and need minimum maintenance.

New York City's 42-story Socony-Vacuum Building, scheduled for completion in 1956, will have 3200 windows, designed to incorporate these features. The windows were designed by engineers of Truscon Steel Div. of Republic Steel Corp. for Harrison & Abramovitz, architects for the building.

The new window has a fully reversible vent, vertically pivoted in its frame, permitting safe, easy



The New C-E La Mont Controlled Circulation Hot Water Boiler

For those applications where high-temperature water has advantages over steam – and there are many – this boiler has many special features such as:

1. **Complete control** over water movement in both system and boiler.
2. **Low pressure loss** makes separate boiler pump unnecessary.
3. **Pressurized operation** with oil or gas means no induced draft fan – simple stack.
4. **Single-pass design** – no baffles . . . low draft loss . . . cleaner boiler.
5. **Other features** such as: steel enclosed setting – few headers, all accessible – any fuel, oil, gas or coal.

Sizes from 15 to 150-million BTU per hour, or more – pressures to 300 psi – temperatures to about 425 F.

MEET YOUR HEATING or PROCESS NEEDS WITH ONE OF THESE C-E BOILERS

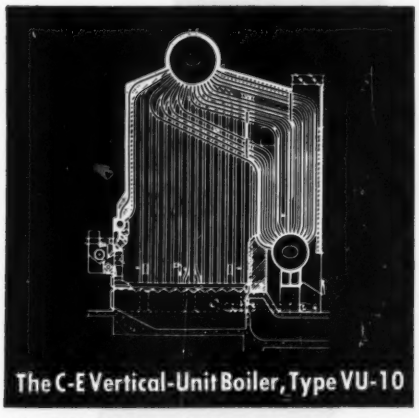
If you need steam – from 4,000 to 60,000 pounds per hour . . . or high-temperature water for heating or process applications . . . one of the three C-E Boilers shown here will fit your needs exactly.

Collectively they offer an exceptional diversity of choice, and a brief consideration of the features of each will help to "pin point" the design characteristics suited to your situation.

Of course, if larger capacities are needed the Combustion line includes boilers of any capacity – for any pressure – for any fuel or method of firing.

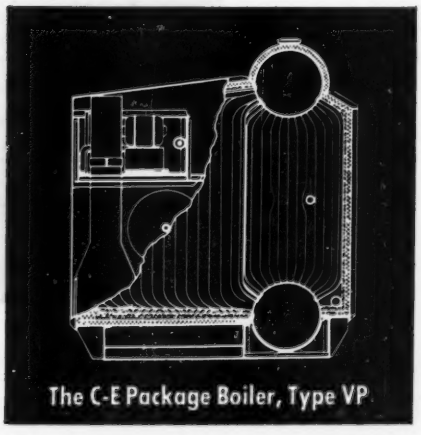
Please feel free to call upon us for further detailed information. Catalogs of each of the units illustrated are available upon request.

B-820A



The C-E Vertical-Unit Boiler, Type VU-10

The VU-10 is available in nine sizes from 10,000 to 60,000 pounds of steam per hour . . . for design pressures up to 475 psi . . . up to 200 degrees of superheat available in 20,000-60,000 lb range . . . for solid, liquid, or gaseous fuels. A completely standardized design adaptable to many conditions and particularly well suited to plants having small operating and maintenance forces. It performs efficiently over a wide range of output, and is easy to operate and to maintain.



The C-E Package Boiler, Type VP

This shop-assembled boiler is available in fourteen sizes from 4,000 to 42,000 pounds of steam per hour . . . for design pressures up to 500 psi . . . up to 200 degrees of superheat available in sizes above 21,000 pounds capacity . . . for pressure firing of liquid or gaseous fuels. The VP Boiler has more water-cooled area per cubic foot of furnace volume than any other boiler of its type. The VP is enclosed in a reinforced, gastight, welded steel casing, and shipped completely assembled with firing equipment, fittings and forced draft fan. For foundation, it needs only a simple concrete slab.

COMBUSTION ENGINEERING

Combustion Engineering Building
200 Madison Avenue, New York 16, N. Y.

BOILERS, FUEL BURNING AND RELATED EQUIPMENT; PULVERIZERS, AIR SEPARATORS AND FLASH DRYING SYSTEMS; PRESSURE VESSELS; AUTOMATIC WATER HEATERS; SOIL PIPE

Windows Designed for Socony Building

—Starts on page 74

cleaning of both sides of the ¼ in. glass pane from indoors. Both vent and frame are fabricated by Truscon from Republic "Enduro" AISI Type 302 stainless steel. New York City cleaning contractors estimate that this free-swinging feature will cut the annual cleaning cost per window from $9.00 for today's conventional double-hung sash to $4.50. In addition, the cleaning operation takes place with the window tightly closed, thus eliminating dirt, noise, air currents, and loss of heated or cooled air.

The window's positive air and watertight seal is provided by a double gasketing of polyvinyl chloride with a combination tube and squeegee weathering section. Gaskets are fitted between stainless steel vent and frame. A development of Truscon and Goodrich Rubber Co., these seamless, electronically-welded gaskets provide two complete vinyl tube squeegee frames at both inner and outer edges of the vent. If severe weather conditions should force any moisture through the outer squeegee frame, the pressure and water are relieved by a drain channel. This tight seal will save $3.54 per window per year in heating and air conditioning costs.

Efficiency of these life-time vinylweather gaskets was demonstrated by two series of tests. The first, at Pittsburgh Testing Laboratories' Pressure Box, subjected the window to direct water spray and static air pressure equivalent to 100 mph wind velocity. Air infiltration amounted to only .014 cu ft per min per linear ft of frame with no water leakage.

The second test, by the University of Miami's Housing Research Bureau, subjected the window to a continuous 100 mph blast of wind and water hurled directly at the window from close range by a 1200-hp aircraft engine. Air infiltration was negligible and there was no water leakage.

Colgate Joins Rensselaer Affiliated College Program

Colgate University is the 17th college or university to join the Rensselaer Polytechnic Institute Affiliated College Program.

Under this "Combined Plan for Liberal Education in Engineering," a student will attend Colgate for three years and Rensselaer Polytechnic Institute for two years and will receive degrees from both institutions, an A.B. degree from Colgate and a B.S. degree from RPI.

According to Dr. Eugene T. Adams, Dean of Faculty at Colgate, "It will offer an opportunity for well qualified students to combine a sound liberal arts background with a first-class technical education. Through our part in it, we hope to help the engineering student to learn to express his ideas clearly and concisely, to give him an understanding of his responsibilities as a citizen and provide him with a knowledge of the background of the social organization in which he lives." ▲▲

CONTINENTAL
Automatic Boiler
Manufactured by:
BOILER ENGINEERING & SUPPLY CO., INC.
Phoenixville, Pa.

- Two-pass design — simple and practical. Range 20 to 500 hp; 15 to 200 lbs. W.P.
- Factory tested before shipment. Guaranteed 80% efficiency.
- Spinning gas technique provides maximum radiant heat transfer from flame to water-cooled furnace walls.
- Even heat transfer — uniform flow of hot combustion gases through all return tubes. All tubes do the same amount of work, are subjected to the same temperatures, expand uniformly.
- Free and rapid water circulation keeps all heating surfaces clean; improves transfer of heat to boiler water.
- High CO_2 and low stack temperature — guaranteed not to exceed 125°F. above saturated steam temperature at operating pressure.

Write for Catalogs BE-3, BE-4

Check these points when you select a boiler:

(1) Fiberglas insulation with metal jacket and metallic paint finish.

(2) Lift lugs for convenient handling on job site.

(3) Boiler shell made of flange quality steel. All joints electrically welded. High pressure shells X-rayed to insure flawless construction and long life.

(4) Separator to assure dry steam supply (99%+).

(5) Dual low water cut-out to provide double insurance against dry firing.

(6) Practical front-end construction that provides open flow of combustion gases to stack. No refractories to maintain. Entire burner front hinged, providing easy access to fire tubes.

(7) Burner enclosed in furnace extension.

(8) Burner and its vital parts — such as fuel nozzles, flame scanner and ignition assembly — fully enclosed in steel housing for safe operation.

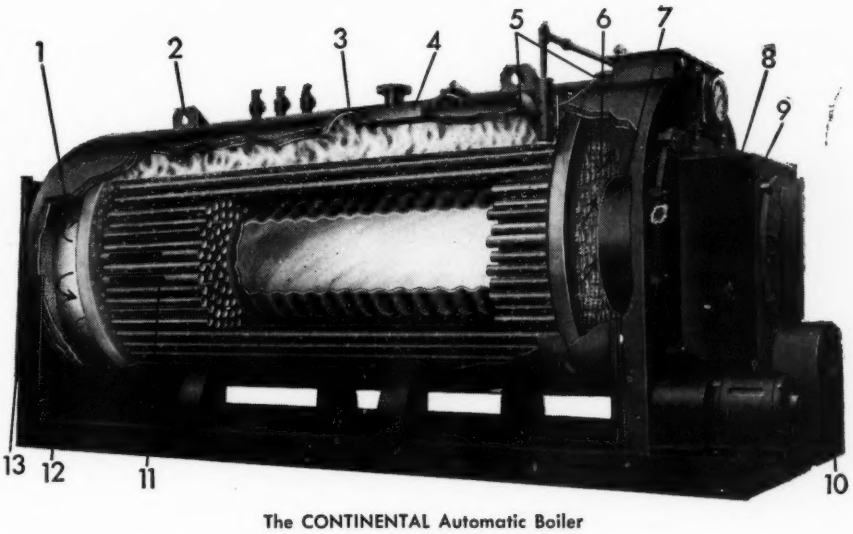
(9) Dual air-flow burner — for oil or gas fuels — precisely fitted to mix fuel and air for high combustion efficiency. Heat transferred directly to water surrounding the furnace.

(10) Air for the burner passes through an inlet silencer to a forced draft fan. Air flow controlled by adjustable dampers.

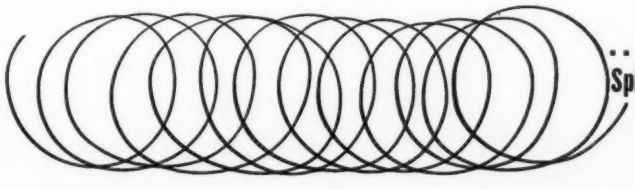
(11) Stationary alloy steel impeller in each return tube to impart spinning motion to hot gases.

(12) Structural steel base distributes weight evenly on boiler room floor. No special foundation required.

(13) Hinged rear door is lined with insulating refractory. Door can be opened in a few minutes — affording access to furnace and all return tubes. No need to remove and replace refractory baffles or brick work. Note sturdy hinge construction which insures positive seating of door.

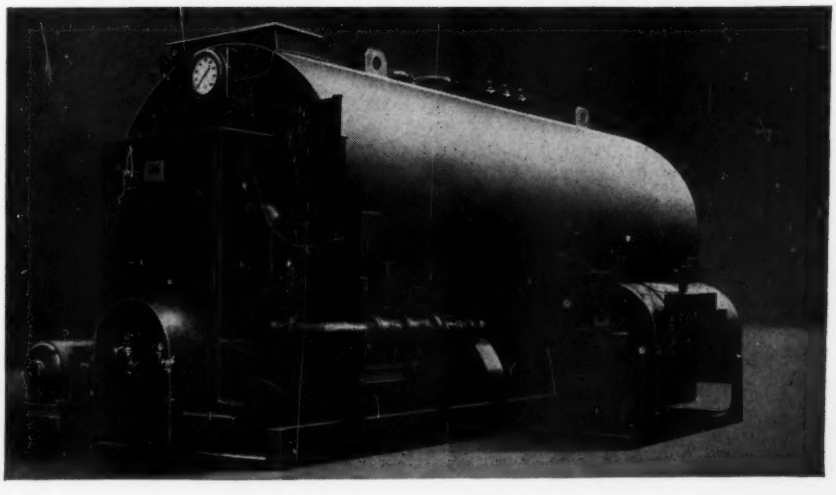


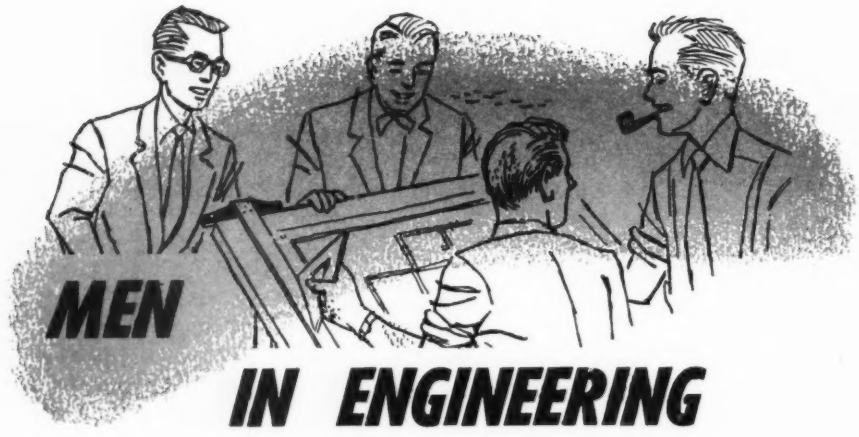
The CONTINENTAL Automatic Boiler



. . . the boiler with the Spinning Gas Technique

Sizes 20 to 500 hp. Pressures 15 to 200 lbs. W.P. Oil, Gas or Combination Fired.





MEN IN ENGINEERING

★ At Luria Engineering Co., Lawrence R. Greenhaus is promoted from sales representative to New York district manager.

★ Stone & Webster Engineering Corp. is awarded the contract for a 200,000 kw steam electric generating unit at the C. R. Huntley station near Tonawanda, N. Y. for Niagara Mohawk Power Corp. When completed in the fall of 1957, the unit will be the largest in use in New York state.

★ Delmer C. Ports, chief engineer of Jansky & Bailey, Inc., is elected to the position of vice president.

★ Brig. General Stewart E. Reimel (ret.) has resigned as Secretary of Engineers Joint Council. He is succeeded by E. Paul Lange, former Assistant Secretary.

★ The Ballinger Co. will be architects and engineers for the tri-project distribution building program in north, south, and west Philadelphia for National Biscuit Co. Exteriors of the one story buildings will be of slag block and brick with poured gypsum and bonded roofing.

★ Dr. Arthur G. Metcalfe, research metallurgist, is promoted to senior metallurgist, highest professional position at Armour Research Foundation of Illinois Institute of Technology, Chicago.

★ Robert W. Marvin is appointed general manager of Dravo Corporation's Engineering Works Div.

★ Dr. Ruben F. Mettler, who received recognition as the outstanding young electrical engineer in the U. S. in 1954, has joined the Ramo-Wooldridge Corp. in Los Angeles. He was formerly special consultant to the Department of Defense as aide to the Assistant Secretary of Defense for research and development in evaluating and planning an important part of the national military weapon system program. Dr. Duane Roller, physicist and former editor of *American Journal of Physics*, joins the company's Guided Missile Research Div.

★ At the Lummus Co., James H. Curtis is elected vice president; D. R. Breien is elected secretary and treasurer; Mario J. Marchione is elected assistant secretary and assistant treasurer; and Theodore F. Brophy is made assistant secretary.

★ Two additional directors have been elected to the board at the Albert Kahn Associated Architects and Engineers, Inc.: R. E. Linton and S. King. Re-elected executive officers are: George H. Miehls, president and treasurer; S. Marston, executive vice president; and G. K. Scrymgeour, secretary. S. Saulson, O. L. Canfield, F. K. Boomhower, R. E. Linton, F. A. Fairbrother, and S. King are vice presidents.

★ G. J. Stegemerten has been awarded the 1955 Gilbreth Medal, an international engineering honor, by the Society for the Advancement of Management. Stegemerten is vice president of Methods Engineering Council, of Pittsburgh.

★ Frederick C. Gardner, president of Ebasco Services Inc., is elected a director of Electric Bond and Share Co. of which Ebasco is a wholly-owned subsidiary.

★ At Lester B. Knight & Associates, Inc., the following appointments were effective May 1: William R. Divine, vice president and manager, Washington D. C. office; Howard W. Maxon, vice president in charge of plant engineering; and Lincoln J. Karmen, manager, New York office.

★ Foster D. Snell, Inc. has promoted Shepherd Stigman to assistant director of personnel and public relations. New additions to the firm are: James Corbett as chemist-pathologist in the bacteriology and toxicology dept.; Murray E. Ferencz as a chemist in the surface chemistry dept.; Morris Glazer as a chemist in the surface chemistry dept.; Sidney

MEN

—Starts on page 78

Gottfried as a chemist in the product development dept. specializing in paints and varnishes; Elias Kimmer as a physical chemist in the product development dept.; Howard F. Kivlin as junior chemical engineer in engineering div.; and Marilyn E. Randall as biologist in the bacteriology and toxicology dept.

★ Hilton A. Levonian is appointed vice president in charge of consulting engineering at The Kuljian Corp.

LEVONIAN

GALLAGHER

★ Patrick V. Gallagher is appointed chief engineer of the Dwight-Lloyd Div. of McDowell Co., Inc., Cleveland, Ohio, industrial contractors and engineers. He was formerly assistant chief engineer of M. H. Treadwell Engineering Co.

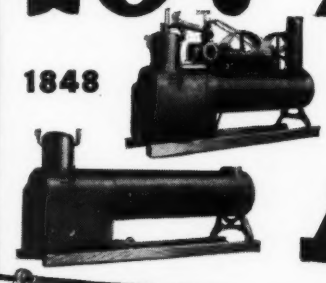
★ Ebasco Services Inc. announces that it is designing and supervising construction of an earth-fill dam near Mt. Hood, Oregon, for Portland General Electric Co. The project is expected to be completed next fall at a cost of $2.5 million.

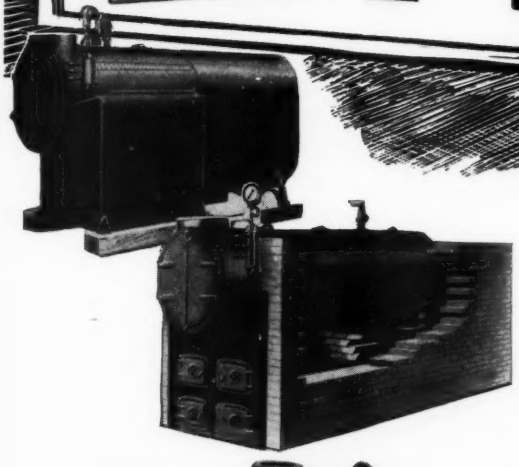
★ Six engineers and executives representing the Spanish electric power industry were guests of Gilbert Associates, Inc., in May. They visited the Titus Station, near Reading, Pa., and the Gilbert offices. Gilbert is designing two 60,000 kw generating stations in Spain for Iberduero, S.A. at Bilbao, and Empresa Nacional Calvo Sotelo at Escatron.

★ At the June convention of the American Institute of Architects, the following manufacturers and associations will receive "certificates of exceptional merit" for product literature and space advertising published in 1954: Accoustical Materials Association, The E. F. Hauserman Co., Architectural Woodwork Institute, and LCN Closers, Inc.

★ Robert Harcus, executive vice president of Byron Jackson Co., is appointed to the Membership Advisory Council of the Atomic Industrial Forum.

107 YEARS of RELIABILITY ARE BEHIND EVERY AMESTEAM GENERATOR





AMESTEAM GENERATOR

20 sizes, 10 to 600 H.P., 15 to 200# W.P., oil, gas, or oil-gas combinations with quick fuel switchover feature.

In your selection of a boiler, it's important to remember — experience *does* count. And what better assurance of top boiler quality do you have than the Ames record: 107 years of building fine boilers — boilers which have given economical, satisfactory service throughout the industry! Many Ames units purchased 40 to 50 years ago are still faithfully on the job. Amesteam Generators always incorporate the latest advances in package boiler design.

Write today for details on these boilers with the proven record of reliability.

AMES IRON WORKS, INC.

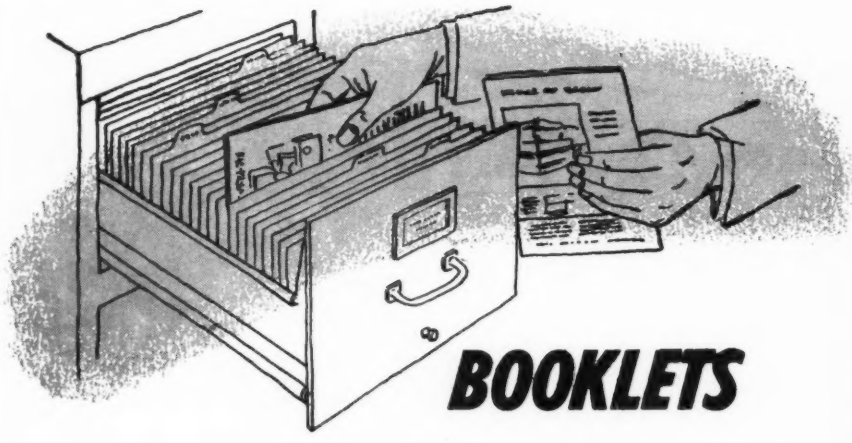
Box P-65, Oswego, N. Y.

Show me how I can benefit from Ames experience and nation-wide organization in getting a top boiler value.

NAME.....

ADDRESS.....

COMPANY.....



BOOKLETS

For copies of these booklets for your files, write on company letterhead directly to address given. For immediate service, telegraph and request Air Mail Delivery.

THE NEWEST MODEL TRANSIT-LEVEL, an instrument between a plain builders' level and a transit, is described in 6-page folder A-17777. Its use for highway work, building, and on other jobs where a surveying instrument is normally used is discussed. *Warren-Knight Co., Dept. CE, 136 N. 12th St., Philadelphia 7.*

"SCIENTIFIC RESEARCH AND DEVELOPMENT SERVICES," 28-page brochure, outlines procedure for inauguration of large or small projects by this laboratory and describes representative services in the fields of chemistry, industrial bacteriology, and chemical and materials engineering. *Truesdail Laboratories, Inc., Dept. CE, 4101-4107 N. Figueroa St., Los Angeles 65, Calif.*

"STEEL GRATING AND TRENDS," 14-page bulletin 2486, gives types, sizes, and load characteristics of the complete line of electroforged steel and interlocked aluminum grating. Installation photographs show the material in use in industry, as sidewalks, and in power plants. *Blaw-Knox Equipment Div., Grating Dept., CE, Blaw-Knox Co., Pittsburgh 38, Pa.*

"CAPACITORS FOR UTILITY SYSTEMS," 16-page booklet B-6136, is arranged to provide maximum aid in selecting the best power capacitor for every application. It matches various applications on transmission and distribution systems to the best capacitor unit for the job. *Westinghouse Electric Corp., Dept. CE, P. O. Box 2099, Pittsburgh 30, Pa.*

BULK CONVEYORS for handling coal, ashes, sand, logs, and similar materials are shown in use in many industries in 12-page bulletin 455. With description of various types of units are drawings of head and tail ends, cross sections, and general arrangement of handling systems. *Jervis B. Webb Co., Dept. CE, 8951 Alpine Ave., Detroit 4, Mich.*

THE NEW JERSEY BID LAW—its history and the progress it has made possible—is outlined in 12-page booklet. Stress is on the amendment passed in 1931 requiring separate plans and bids for structural steel and ornamental iron work. *Structural Steel and Ornamental Iron Association of New Jersey, Inc., Dept. CE, 11 Commerce St., Newark.*

"DESIGN BOOK," 20-page technical bulletin 125417, points up the versatility of mechanical and industrial felts and the range of available felt products. Recommendations are given for the use of various types of felt. *The Felters Co., Dept. CE, 210 South St., Boston 11, Mass.*

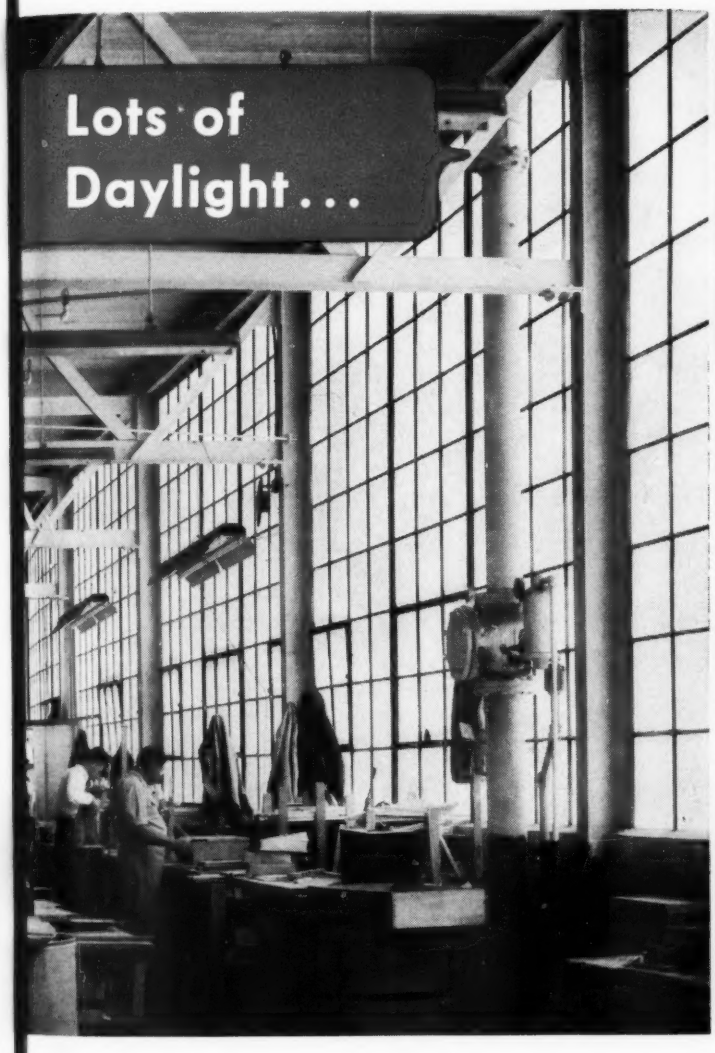
FOR IMMEDIATE SERVICE
If you would like immediate service, wire to address given and request Air Mail Delivery.

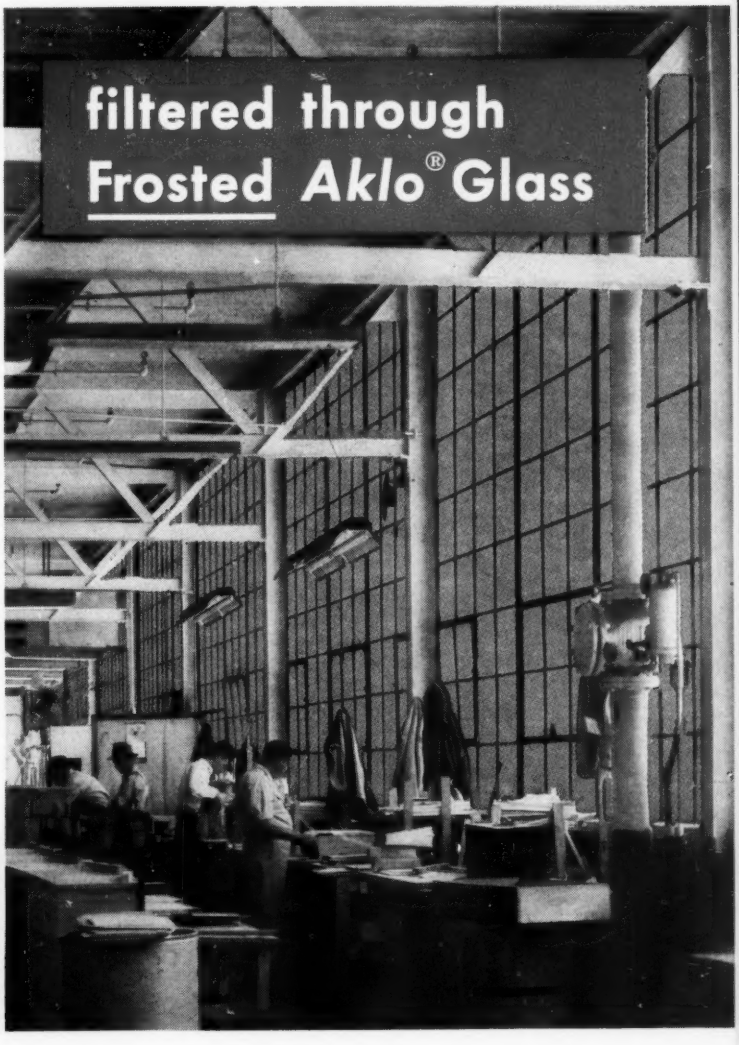
"AUTOMATION AND AUTOMATIC MACHINERY," 4-page booklet, outlines the engineering and design services offered by this company and lists 17 projects completed since 1948 in the medical, graphic arts, aviation, packaging, and industrial fields. *The de Florez Co., Inc., Dept. CE, 116 E. 30th St., New York 16, N. Y.*

"MOTORS—BUYING INFORMATION," 28-page catalog GEC-1026, presents complete buying information on standard a-c fractional and integral horsepower motors in most general use. Included are general and definite purpose fractional horsepower motors and fhp gear motors. *General Electric Co., Dept. CE, Schenectady 5, N. Y.*

CLOSE-COUPLED MOTORPUMPS from ¼ to 75 hp sizes for delivery of 5 to 2800 gal per min. are covered in 24-page bulletin 7093-E. Designed to make selection of the correct size and model simple, the booklet includes sample problems and pipe

Formula for good seeing:





Take two things out of daylighting—glare and sun heat—and you have the finest light for good workmanship.

That's just what Frosted *Aklo* Glass does for you. It softens and diffuses direct sunlight, sky brightness and dazzling reflections. Rooms not only seem cooler behind this glass . . . they *are* cooler. *Aklo* Glass in ¼" thickness shuts out as much as 44% of the sun's radiant energy.

These are good reasons why you see blue-green *Aklo* Glass in the window walls of so many of today's new buildings.

The pay-off? Greater comfort for occupants, better workmanship, better employe relations, reduced air-conditioning costs.

PHONE FOR THIS TEST

A call will bring a radiometer demonstration kit to your desk. It shows you how *Aklo* Glass reduces glare and sun heat. Call your L·O·F Glass Distributor or Dealer listed under "Glass" in the yellow pages of your phone book. Or write to Libbey·Owens·Ford Glass Company, 608 Madison Avenue, Toledo 3, Ohio.

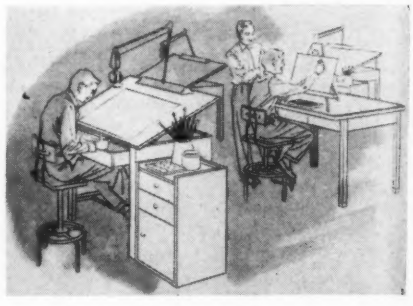
AKLO GLASS **FILTERS DAYLIGHT**

made by Blue Ridge Glass Co.
sold by Libbey-Owens-Ford Glass Distributors

BOOKLETS —Starts on page 82

friction tables. *Ingersoll-Rand, Cameron Pump Div., Dept. CE, 11 Broadway, New York 4, N.Y.*

DEALKALIZING SALT SPLITTER for chemical plants, textile mills, and medium size power plants where alkalinity of water is undesirable is described in bulletin 4567. How the unit can operate by completely automatic cycling is explained. *Cochrane Corp., Dept. CE, Philadelphia 32, Pa.*



DRAFTING FURNITURE—The entire line of Life-time steel drafting and file equipment is described in 20-page catalog 554-PTD. It is planned to give you complete working knowledge of the equipment and shows how various units are adaptable to specific business and industrial needs. *Stacor Equipment Co., 768-778 E. New York Ave., Dept. CE, Brooklyn 3, N. Y.*

"PERFORMANCE CHARACTERISTICS OF 150 C RISE DRY-TYPE TRANSFORMERS," 8-page bulletin 61R8246, discusses new insulation methods and material. Curves show strength of solid Quinterra asbestos paper insulation, 60-cycle dielectric strength versus temperature of air at 1-in. spacings, and silicone-resin treated Quinterra under static conditions. *Allis-Chalmers Mfg. Co., Dept. CE, Milwaukee 1, Wis.*

"AMERICAN STANDARDS, 1955 EDITION," 48 pages, lists and indexes some 1500 standards including those for construction and civil engineering, mechanical, electrical, metallurgical, and chemical. *American Standards Association, Inc., Dept. CE, 70 East 45 St., New York 17.*

NEW APPLICATIONS FOR THE METALPHOTO PROCESS of photographic reproduction on photosensitive aluminum plates are described in 4-page report. Exposing and developing the plates, adaptation for color and three-dimensional effect, and general properties are covered. *Metalphoto Corp., Dept. CE, 2903 E. 79th St., Cleveland 4, Ohio.*

MUNICIPAL AND INDUSTRIAL WASTE treatment equipment for all water

BOOKLETS —Starts on page 82

and waste conditioning processes is presented in 4-page bulletin WC-117. Photographs of typical installations are accompanied by a short description of the equipment. *Graver Water Conditioning Co., Dept. CE, 216 W. 14th St., New York 11, N. Y.*

CODE LIBRARY—Problems that can be solved through use of the computational facilities and the code library at Midwest are discussed in 16-page bulletin. It describes specialized equipment available to handle all types of problems and the use of this service. *Computation Center, Midwest Research Institute, Dept. CE, 425 Volker Blvd., Kansas City, Mo.*

FOR IMMEDIATE SERVICE

If you would like immediate service, wire to address given and request Air Mail Delivery.

"DATA AND SPECIFICATION MANUAL," 16 pages, contains safe load tables for all basic types of gratings, panel width constant charts, tables on standard widths and types of steel stair treads, anchors used for grating, use of grating in industry and the oil and chemical fields, and tables on bridge decking and drain grates. *Klemp Metal Grating Corp., Dept. CE, 6605 South Melvina Ave., Chicago 38, Ill.*

"AUTOPOSITIVE IN ACTION," includes seven case histories which show techniques employed by various firms in using this product for engineering drawing reproduction. Suggested uses are also given. *Eastman Kodak Co., Graphic Reproduction Div., Dept. CE, Rochester 4, N. Y.*

"HEAVY-DUTY DIESEL ENGINES," 20-page bulletin 10,040, provides complete information on lubrication, cooling, and fuel injection systems of the Type "S" and "SS" engines in sizes from 375 to 1000 hp. *Ingersoll-Rand Co., Dept. CE, 11 Broadway, New York 4, N. Y.*

DRAFTLESS AIR DIFFUSERS — This 64-page selection manual is a guide book to conventional and high velocity draftless air diffusers. Special section on high velocity units will be of particular value to architects and consulting engineers in the air conditioning field. *Anemostat Corp. of America, Dept. CE, 10 E. 39th St., New York 16, N. Y.*

ZEOLITE WATER SOFTENERS — Troubles caused by utilization of hard water and multiple economies effected by curing them are dis-

BOOKLETS —*Starts on page 82*

cussed in 20-page bulletin 2386-A. Specifications, operating characteristics, and typical installation photographs of Zeolite water softeners will be of interest to all engineers dealing with water problems. *The Permutit Co., Dept. CE, 330 W. 42nd St., New York 36, N.Y.*

FOR IMMEDIATE SERVICE
If you would like immediate service, wire to address given and request Air Mail Delivery.

CHOOSING THE PROPER TYPE of automatic control system to meet process requirements is made easier with the use of 16-page bulletin #9. It discusses conventional millivoltmeter construction and application to a control instrument and the function of an oscillator circuit to a pyrometer controller. *Barber-Colman Co., Wheelco Instruments Div., Dept. CE, Rockford, Ill.*

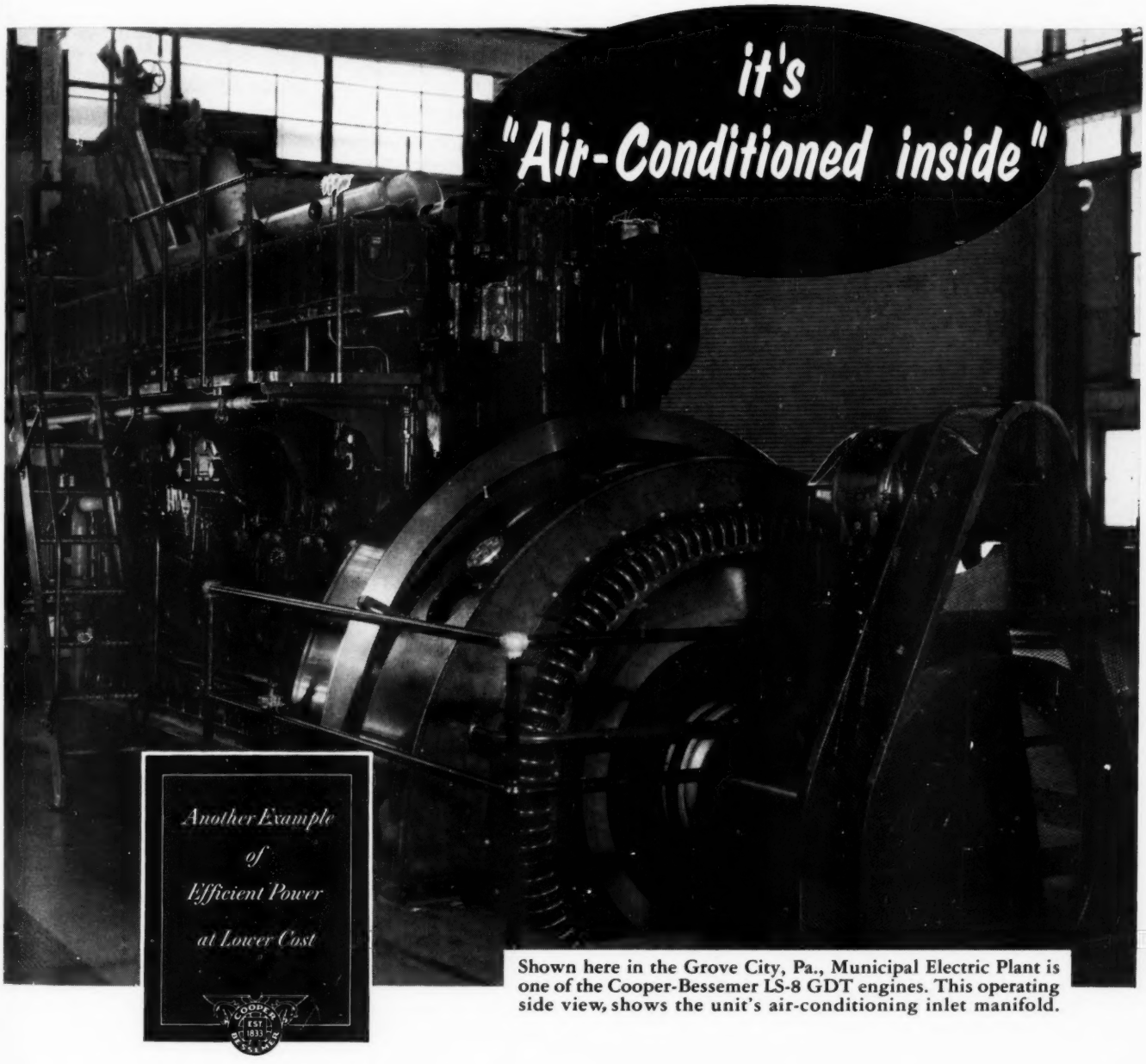
"A GUIDE FOR THE SELECTION OF ELECTRIC CONDUCTOR ACCESSORIES," 12-page manual, provides information on accessories used with aluminum wires and cables in construction of overhead electric transmission and distribution lines. *Reynolds Metals Co., Cable Div. PR, Dept. CE, 2500 S. Third St., Louisville 1, Ky.*

CONCRETE BLOCK—This color pamphlet gives details on Ranch Rock, a mass-produced split concrete block with a quarried stone appearance. Examples are given of its use as a building material for office buildings, schools, and homes and also as an accent in entry ways and similar uses. *The Marietta Concrete Corp., Dept. CE, Marietta, Ohio.*

FOUR-PAGE BULLETIN AH-467 describes the Gyrotor Air Classifier for the continuous separation of an airborne mixture of coarse and fine particles. Operation principle, typical applications, and various possible arrangements are discussed and shown in drawings. *Hardinge Co., Dept. CE, 240 Arch St., York, Pa.*

FOR SALE

The LS-8 at Grove City Municipal...



Shown here in the Grove City, Pa., Municipal Electric Plant is one of the Cooper-Bessemer LS-8 GDT engines. This operating side view, shows the unit's air-conditioning inlet manifold.

NEW is a good word to describe the air-conditioned Cooper-Bessemer LS-8 in operation at the Grove City, Pa., Municipal Electric Plant. Rated 1500 KW capacity at 80% power factor, this engine is an outstanding improvement over previous LS-8's which were rated 1250 KW.

This KW increase results, in part, from vapor injection —actually, air-conditioning built into the air intake manifold. No need to pre-cool the air before the supercharger . . . only a standard after-cooler installed between the supercharger and the air inlet manifold. Water, sprayed into the manifold at the rate of five gallons per minute, humidifies and further cools the air before it enters the engine cylinders. Excess water is removed from the air through baffles and a drain off.

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Expert Witness

—Starts on page 41

such circumstances, can you be friendly, responsive, politely critical when necessary, reasonably quick in thinking, and convincing in your statements? ¶ Do you enjoy the challenge of answering technical questions before a large audience, such as in engineering conferences, meetings or conventions? In so doing, can you think quickly enough to say about everything you wish in completing your answers—without later recalling many other points you should have included?

An expert witness should possess the attributes implied by the foregoing questions as a safety factor against being overwhelmed in the event verbal fireworks should occur. However, conditions are generally friendly, businesslike, and conducted with excellent decorum.

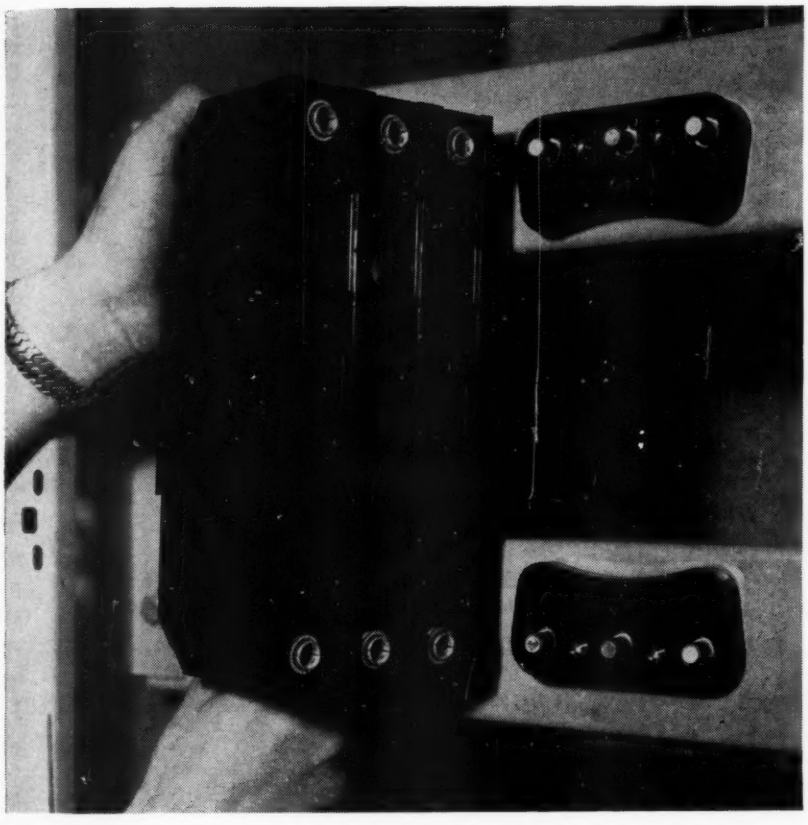
In retiring successfully from the witness stand, commendations from his principals are not really needed for assurance of a job well done. (Attorneys will most probably give no praise regardless of how excellent the testimony for fear that the expert may use these compliments as a justification for inflating his bill for the service.) However, the expert will know full well whether his testimony was successful, mediocre, or a failure. Mediocrity or failure will be self-apparent. The resulting disappointment and chagrin of the expert can disturb his peace of mind for weeks to come. On the other hand, he will be as glowingly self conscious of his successes, as is the pinch-hitter who brings in a grand slam home run.

While his testimony is still reasonably fresh in mind, the expert witness may immeasurably improve the quality of future appearances on the witness stand by making a study of his recent experience as set forth in the trial records. He could well devote several hours to advantage in preparing notes on the successful highlights of his testimony as well as on his less fortunate experiences.

If an engineer-expert anticipates appearing again on the witness stand or has an actual court case in the offing, his success in the future venture will depend largely on the degree of his mental preparedness for the occasion. Assuming that the case is well prepared in its factual foundations and that an excellent tenable theory has been formulated, the expert witness still has many facets of a personal nature to polish. Invaluable preparation comprises a final review of the physics in the case — refreshing one's mind and memory on the broadly related theory, principles, equations, calculations, and basic factual data. This amounts to cramming.

Experience has shown that elaborate preparation for trial is rewarding. It pays off with high dividends of satisfaction in a job well done, success in winning the court case, and development of tactical capabilities.

Specify I-T-E Plug-In Mounting for Molded Case Circuit Breaker Switchboards



IT'S EASY TO MOUNT an I-T-E Molded Case Circuit Breaker when it is equipped with plug-in arrangement. Simply place the integral connectors over the stationary jacks and seat the breaker. It's safe too. All terminals are shielded to provide maximum protection to the worker.

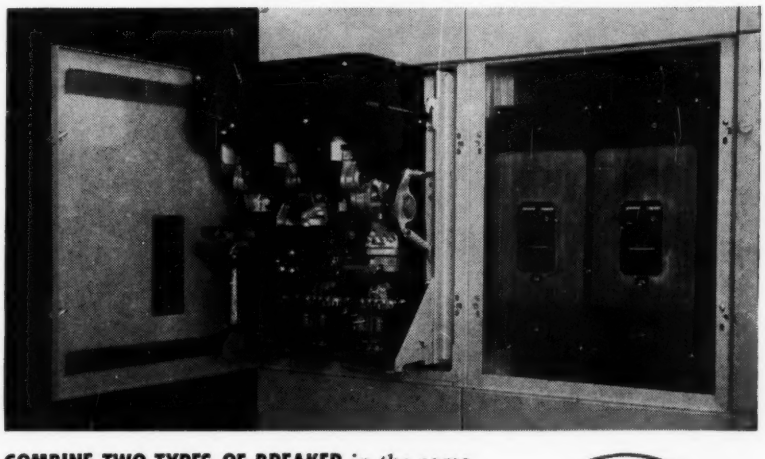
Why settle for less! I-T-E Molded Case Circuit Breakers designed for plug-in mounting in switchboard applications provide features and advantages you get only in this modern, streamlined construction. Plug-in mounting is a time-proved method employed for many years in maritime switchgear, and is approved by Underwriters Laboratories Inc.

Here are some of the advantages of I-T-E Plug-In Mounting: *Added Safety*. Breaker terminals are concealed. No live parts exposed. *Flexibility*. Breaker ratings can easily be changed within their respective frame sizes. *Ease of Installation*. Breakers simply *plug in*. Molded supporting block assures automatic alignment.

Investigate I-T-E Plug-In Mounting before specifying your next molded case breaker switchboard. I-T-E plug-in molded case circuit breakers are available in ratings from 15 to 600 amp, up to 600 v a-c, up to 250 v d-c.

For details, contact your I-T-E representative or leading independent switchboard manufacturers. Or write Small Air Circuit Breaker Division, I-T-E Circuit Breaker Company, 19th & Hamilton Sts., Philadelphia 30, Pa.

FLEXIBILITY. Withdraw one breaker, insert another of the same frame size with the desired continuous ampere rating. No wiring changes, no tools needed. All I-T-E Molded Case Circuit Breakers can be supplied with plug-in mounting arrangement.



COMBINE TWO TYPES OF BREAKER in the same switchboard. Large air circuit breaker pantograph mounted for horizontal drawout. Molded case circuit breakers plug in mounted for easy installation and replacement.

I-T-E CIRCUIT BREAKER COMPANY • **Small Air Circuit Breaker Division**

—*Starts on page 54*

tions to other than boiler feed pump drives reached such proportions during the past 10 to 15 years that sufficient knowledge and experience have been accumulated to prove that this equipment is highly reliable and capable of meeting the rigid demands of central power station service. High speed gears should be suitable for 80,000 to 100,000 hours of operation without opening the gear case for overhauls if certain basic precautions are taken:

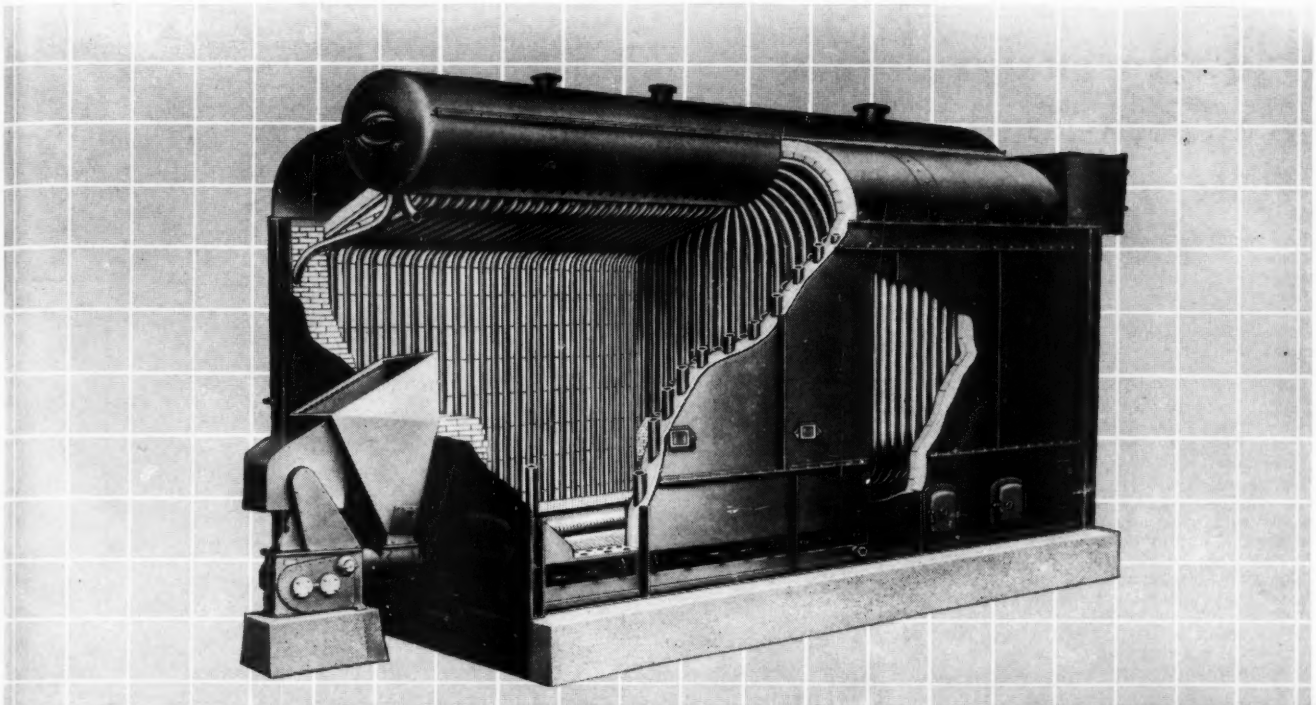
Precautionary Measures

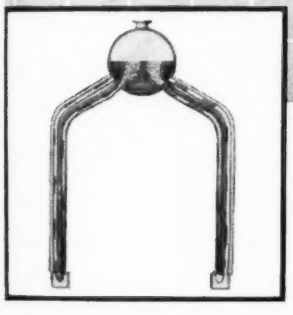
¶ Proper attention should be paid to the gear selection so as to avoid gear overload. All too few consultants know enough about specifying gearing.
¶ Good alignment should be maintained between the driver, the gear, and the driven equipment. This requires sound foundations and careful alignment.
¶ Proper oil level should be maintained in the gear. The oil should be kept clean and free from foreign material and should be replaced as required.
¶ No excessive lateral or torsional vibration should be transmitted from either the driver or the driven equipment to the gear.
¶ After a short time of initial operation, the gear should be opened to make sure that the teeth are wearing-in correctly.

This last item is extremely important to the ultimate life of the gears. If the gears are properly lubricated, the rolling and sliding action of the teeth will act to smooth out and polish the teeth surfaces during the initial running-in of the unit. After this, there should be little or no wear on the gear teeth if proper operating conditions are maintained. It is important, however, to keep a careful check on the oil initially used, since this smoothing out and polishing operation will allow small particles of metal to enter the oil reservoir and be carried into the oil circuit. Such contaminating particles will cause serious wear if allowed to remain in the oil. They must be removed by filtration or by an oil change before they damage the gears.

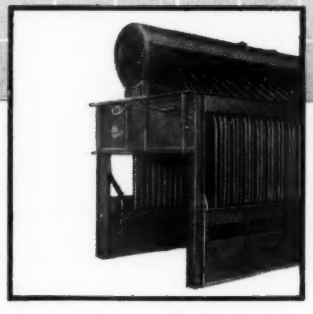
Noise Rating

A great deal has been written and said concerning the noise level of high speed gears. Experience gathered in the design and manufacture of high speed gears used to drive centrifugal refrigeration compressors for building air-conditioning, where there is a serious objection to noise, has resulted in designs quite acceptable from this point of view. Gear noise is no longer a major problem in the application of high speed gears to boiler feed pump drives. As a matter of fact, the author can point to several installations where the decibel readings of the gear noise are lower than those of the electric motors themselves.

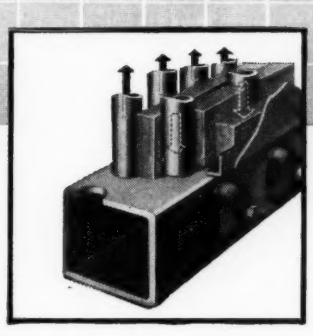




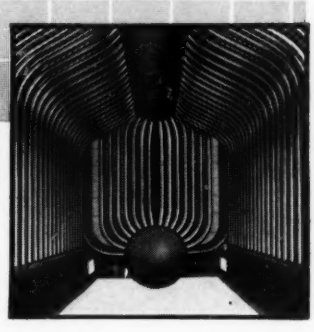
RING-FLOW CIRCULATION IN EACH WATER WALL ELEMENT



POSITIVE WATER SUPPLY TO WATER WALLS



WATER WALLS ACCESSIBLE FROM OUTSIDE THE SETTING



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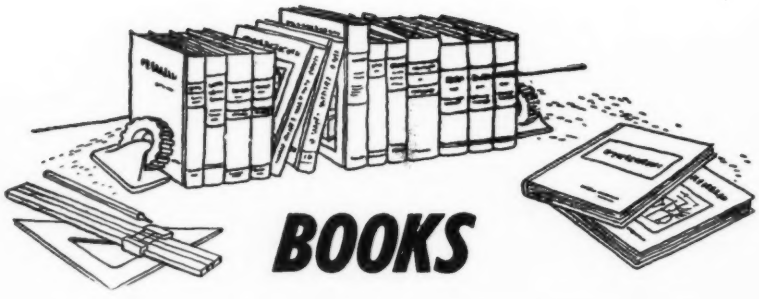

BOOKS

TO ORDER BOOKS

As a readers' service, CONSULTING ENGINEER will order reviewed books or any other technical volumes you need. In ordering books, give title, author, and publisher and enclose check. We will also suggest titles of books on any technical subject and order for you at regular publishers' prices.

TITANIUM IN IRON AND STEEL, by George F. Comstock; John Wiley and Sons, Inc.; 294 pp; $6.00.

Reviewed by F. W. Boulger
Battelle Memorial Institute

Experimental data pyramid so rapidly these days that engineers and metallurgists have a difficult time keeping up with the technical literature. This situation increases the need for accurate, concise reviews of information available on specialized topics. *The Alloys of Iron Monographs* are intended to meet this challenge by summarizing and evaluating all pertinent publications in certain fields of ferrous metallurgy. This book is the third volume in the new series of monographs.

The addition of titanium confers special characteristics on iron alloys. The author investigated and studied these effects for more than thirty years. The experience was particularly helpful in sifting and correlating information originally presented in 282 technical publications, numerous patents and unpublished reports prepared by private laboratories. In so far as possible, the findings of laboratory studies are evaluated by comparisons with commercial experience and practices. The conclusions were verified when the monograph was reviewed by a committee representing 16 companies concerned with metal production or processing.

The text is tersely written in a pleasing style and carefully edited. The illustrations are excellent. The book is well organized in ten chapters and indexed for easy reference. The short introduction mentions the principal sources of ore and briefly describes the properties and methods of preparing pure titanium and titanium-base alloys. Separate chapters describe the behavior of titanium as a deoxidizer and as a stabilizer for carbon, sulfur, and nitrogen. These are the principal contributions of titanium in iron-base alloys. Other chapters show the influence of these effects on the properties of enameling irons, pearlitic steels, cast steels, cast iron, high-chromium steels, low-alloy steels, and heat-resistant alloys. The discussions are supplemented by data presented in tables.

The book includes most of the material covered in *Titanium in Steel,* prepared by the same author and two associates, which was printed in 1949. The scope was expanded to cover cast iron and the presentation brought up to date by considering about 85 publications available since the earlier book was prepared.

Titanium in Iron and Steel is a worthwhile contribution to the literature on the effects of alloying elements in iron-base alloys. The book should be of special interest to research metallurgists and materials specialists.

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MAGNETIC AMPLIFIERS, by Dr. H. F. Storm; John Wiley & Sons, Inc.; 545 pp.; $13.50.

Reviewed by R. M. Bergslien
Armour Research Institute

A very thorough presentation of the theory, practical considerations, and application of the most common types of magnetic amplifiers. The theory is organized in an orderly manner beginning with the simple saturable reactor and progressing through the self-saturating magnetic amplifier with external feedback. The newer type inherently fast response magnetic amplifiers are only briefly mentioned. Operation of the various types of magnetic amplifiers covered in the book is explained in a clear and concise manner.

Noteworthy features are separated sections on the theory of magnetism,

General Contractor: Chemical Construction Company, 488 Madison Ave., N.Y. *Approved Corrugated Asbestone Contractor: Taylor-Siedenbach, Inc., New Orleans, La.*

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Weights and sizes:	Standard 400
Width	42"
Lengths	1' to 12' (in 6" increments)
Thickness	Approx. 3/8" at the crests and vales, 5/16" at flanks.
Pitch	4.2"
Weight	4 lbs. per sq. ft.
Color	Natural Cement Gray
Depth of Corrugation	1½"
Applications Specifications:	
Minimum Roof Slope	3" rise in 12"
Maximum purlin (roof) spacing	4'-6"
Maximum girt (side wall) spacing	5'-6"
Weight per net square, including side and end laps	Approx. 500 lbs.
Minimum side lap	1 corrugation (4.2")
Minimum end lap	6"

Refer to Sweets—AIA File 12-F

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magnetic amplifier core materials, magnetic testing, construction and manufacturing techniques used in producing saturable reactors, and rectifier characteristics. This information should be very useful to the designer and consultant.

From the viewpoint of the consulting engineer the numerous applications cited should be of prime interest. General areas of application covered are power control, phase control, instrumentation, servomechanisms, current and voltage regulators, speed and frequency controls, and nonlinear circuit elements. Abundant use of simplified circuit diagrams permits the reader to obtain rapid understanding of specific applications.

This book should be a valuable reference to all those interested in this field.

ALSO AVAILABLE

INDUSTRIAL ENGINEERING TERMINOLOGY; The American Society of Mechanical Engineers; 50 pp; $1.50.

This book includes 500 industrial engineering terms arranged in alphabetical order and defined briefly and in non-technical terms. Subjects range from elementary definitions, such as those for industrial engineering or for a standard itself, to an entire series of complex production terms. Various instruments such as the marstochron and the kymograph are included.

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THE APPLICATION OF OPERATIONS RESEARCH TO INDUSTRY; U. S. Department of Commerce; $1.75.

Techniques of scientific analysis, borrowed from military tactical operations, are applied to industrial planning in this book. It describes functions of the operations analyst and his relations to the executive, the analytical tools used in operations research, and gives case histories. It includes a check list for solving action problems, and gives references.

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GEOLOGY IN ENGINEERING, by John R. Schultz and Arthur B. Cleaves; John Wiley and Sons, Inc.; 592 pp; $8.75.

This book supplies a systematic account of geologic principles and methods for use by the practicing engineer. The emphasis is on soils and soil mechanics, although the book also gives detailed attention to minerals, rocks, geologic structure, historical geology, and related subjects. Several chapters are devoted to landslides and related phenomena, maps and sections, aerial photographic interpretation, and dams and reservoirs. ▲▲